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Irrigation & Water Conservation

PM dedicates Sardar Sarovar Dam to the Nation

The Prime Minister, Shri Narendra Modi at the Sardar Sarovar Dam, in Gujarat on September 17, 2017.

The Prime Minister, Shri Narendra Modi dedicated the Sardar Sarovar Dam to the nation on 17th September, 2017. The occasion was marked by prayers and chanting of hymns at the Dam at Kevadia. The Prime Minister also unveiled a plaque to mark the occasion.

The Sardar Sarovar Project is one of the largest water resources project of India covering four major states - Maharashtra, Madhya Pradesh, Gujarat and Rajasthan. Dam's spillway discharging capacity (30.7 lakhs cusecs) would be third highest in the world.

With 1133 cumecs (40000 cusecs) capacity at the head regulator, and 532 km. length, the Narmada Main Canal would be the largest irrigation canal in the world.

The dam will be the third highest concrete dam (163 meters) in India, the first two being Bhakra (226 metres) in Himachal Pradesh and Lakhwar (192 meters) in Uttar Pradesh. In terms of the volume of concrete involved for gravity dams, this dam will be ranking as the second largest in the world with an aggregate volume of 6.82 million cu.m. The first is Grand Coule Dam in USA with a total volume of 8.0 million cu.m. This dam with its spillway discharging capacity of 85,000 cumecs (30 lakh cusec), will be the third in the world, Gazenba (1.13 lac cumecs) in China and Tucurri (1.0 lac cumecs) in Brazil being the first two.

The reservoir would occupy an area of 37,000 ha. and would have a linear stretch of 214 kilometer of water and an average width of 1.77 kilometer. The Full Reservoir Level (FRL) of the Sardar Sarovar Dam is fixed at RL 138.68 metres (455 feet). The Maximum Water Level is 140.21 metres (460 feet.) while minimum draw down level is 110.64 metres (363 feet.). The normal tail water level is 25.91 metres (85 feet.).

Irrigation from the project is expected to benefit about 10 lakh farmers, and drinking water to be supplied to various villages and towns, is likely to benefit upto 4 crore people. The project has been described as one of largest ever human endeavours for water transport. Upto a billion units of hydropower are also expected to be generated annually.

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CONTENTS

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Editorial

Water is life – for everyone. But it is even more important for a country like India where a large section of population still depends on agriculture for its livelihood, and Indian agriculture is still described as 'the gamble with monsoon'. This gamble, more often than not, results in some unforeseen circumstances for the farmers of our country. To reduce this dependence on rains, all societies have been devising various irrigation systems since ancient times.

But despite their best efforts, even today, Indian farmers' fate, and hence Indian economy's, is tied to the monsoons to a great extent. A positive monsoon forecast from Met Department still has the potential to raise share markets in Mumbai. To minimise these losses arising due to vagaries of the nature, the Government has been laying a lot of emphasis on increasing irrigation facilities in the country. **Pradhan Mantri Krishi Sinchayee Yojana** (PMKSY) is the flagship program of the Government which aspires to bring water to every field - **Har Khet Ko Pani**. Numerous irrigation projects stuck for years are being accelerated under this scheme and new ones are being conceived to ease the burden on the farmer.

Having said that, it needs to be stressed that creating irrigation capacity alone is not sufficient in itself. We have to increase water use efficiency in every sphere of life as well. This is even more so as the burgeoning population and people's consuming lifestyles have been putting tremendous strain on the limited natural resources of the country. As a matter of fact, India supports 16 per cent of the world population with a mere two per cent of the land area. Situation demands that the existing water and land resources be used very judiciously and prudently. Not doing so may, or rather would, endanger the future of our coming generations. Unrestrained exploitation of the precious ground water has depleted water table at an alarming rate in several parts of our country. The situation can only be reversed by improving water use efficiency in irrigation and in our daily lives. Keeping this in mind, the Prime Minister has, time and again, called for producing **'More Crop, Per Drop'**. This simply means promoting the use of micro-irrigation technologies such as sprinkler and drip irrigation, which minimise the wastage of water in irrigation.

In addition, we should spare no effort in conserving every single drop of water that mother nature provides us. For this, we have to make every effort from the watershed management to rooftop rainwater harvesting ... to recycling and reusing the water in our kitchens and gardens. In this process, we can greatly benefit from the knowledge of our ancestors who practiced a number of traditional water conservation methods. Every part of our country has a rich heritage of these methods for irrigation and water conservation such as – Jhalara, Bawari, Kuhls etc.

But these efforts for the conservation of this precious resource can succeed only when people themselves take upon the responsibility for it. Governments alone can not ensure this. Water conservation has to become a part of our everyday life. It has to become a mass movement – a people's movement, only then we will be able to gift an India to our future generations where land is green and water flows in every tap.

MORE CROP PER DROP: EFFICIENT IRRIGATION WATER USE

S K Sarkar

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, particularly in rural areas. More than 70 per cent population in India is rural, and is dependent on agriculture directly or indirectly and so Monsoon plays a big role in the economy. The Monsoon is the real Finance Minister, it is often said.

Globally, only 0.4 per cent of total water on earth is at our disposal for meeting our needs. Fourteen per cent of world population shares 53 per cent of total water resources, while 86 per cent of world population (including China, India) shares 47 per cent of global water resources. India's share of World's water resources is only 4 per cent although it contributes 17 per cent of world population.

Water resources are essential, inter alia, for life, livelihood and ecology. They are vital for economic development, and are also crucial for food security, national security and energy security. Given the estimated annual precipitation (including snowfall) of 4000 BCM (billion cubic meter), only 1123 BCM water can be used for various purposes, comprising of 61 per cent of surface water and the rest as ground water. An estimate (NCIWRD 1999[1]) shows that by 2050, the water demand is likely to be at about 73 per cent in irrigation sector, followed by industry and domestic sectors. Currently, this share is about 80 per cent.

There are spatial and temporal variations of water availability. For example, 75 per cent of rainfall in India occurs in 4 months with highest precipitation in North-East region and lowest in Rajasthan. The per capita availability of water resources is declining over the years, it is estimated to touch the water scarcity zone by 2050. Even today, India's per capita water availability is low compared to countries such as Brazil, Australia, USA, UK, Bangladesh and China.

To support 1.7 billion populations (2050), India will need 450 MT (Metric Tonnes) cereals. Status of irrigation development shows that the assessed irrigation potential is about 140 mha (million hectare) while actual realized irrigated area is far less, suggesting further scope of improvement through use of various measures. In addition, there is low productivity per unit use of water raising concern in the context of India's growing population. For example, irrigation water withdrawal for rice production is 3.48 BCM/yr/mha (million hectare) while the same for Myanmar is much more efficient at 1.90 BCM/yr /mha. The crop yield in general is very low; for rainfed areas, it is about one tonne/ha while for irrigation area, the same is 2.5 Tonnes/ha.

Agricultural sector, although consuming about 80 per cent of India's water resources, suffers from low water use efficiency (about 38 per cent). It is specially important as India being an agrarian economy, is largely dependent on farm cultivation for fulfilling its basic needs. In fact, irrigation is a major input cost in agriculture amounting to about 70 per cent of total input cost. Increasing water use efficiency means water saving leading to lower input cost.

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, particularly in rural areas. More than 70 per cent population in India is rural, and is dependent on agriculture directly or indirectly and so Monsoon plays a big role in the economy. The Monsoon is the real Finance Minister, it is often said.

In the irrigation conveyance system, there is significant water loss by the time water reaches the tail end due to inefficiencies in conveyance system. The conventional irrigation water use, such as through canal and flood irrigation, has efficiency varying for 55 to 66 per cent while the improved micro irrigation systems using drop and micro irrigation technology has efficiency above 90 per cent. A huge amount of water loss in canal and flood irrigation occurs due to evaporation, percolation and seepage. In contrast, the closed pipe network reduces this loss significantly.

Definition:

Efficiency is the ratio of output to input and is expressed in percentage. The objective of efficiency concept is to show what improvements can be made which will result in more efficient irrigation. Various types of irrigation efficiency are used. First, water conveyance efficiency takes into account the conveyance and transit loss, and is determined as a ratio of water delivered to farm or irrigated plot over the water supplied or diverted from river or reservoir. Second, 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 stored into the root zone of the crops over the quantity of water delivered to the field. In a well designed surface irrigation system, the water application efficiency is at least 60 per cent while in sprinkler irrigation system, it is about 75 per cent. Low water application efficiency is due to, inter alia, irregular land surface, wrong irrigation methods, steep slope of land surface, etc. Fourth, water use efficiency is the ratio of water consumptively used to the quantity of water delivered. Fifth, water storage efficiency gives an insight to how completely the required water has been stored in the root zone during irrigation. It is the ratio of water stored in the root zone during irrigation and the water needed in the root zone prior to irrigation. Finally, the water distribution efficiency evaluates the degree to

which the water is uniformly distributed throughout the root zone. The more uniformly the water is distributed, the better will be the crop response.

Steps for Water Conservation:

The demand of water in all sectors including irrigation is increasing. However, there is a limited supply of water resources. In addition, there is a threat from climate change effects which will further reduce availability of water resources. The contamination of water sources, both ground water and surface water, reduces further the availability of usable water. To meet the increasing demand, there is a need for water conservation and reducing water contamination in all sectors. Further, there is a need for increasing water use efficiency in all the sectors. There are many steps that could be adopted for water conservation in irrigation sector. These include:

- Proper and timely system maintenance.
- Rehabilitation and restoration of damaged and silted canal system to enable it to carry designed discharge.
- Conjunctive use of surface and ground water, especially in areas where there is a threat to water logging.
- 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.
- Constitution of water user associations and transfer of management to them.
- Promoting multiple uses of water.
- Introducing night irrigation practice to minimize evaporation loss.
- Assuring timely and optimum irrigation for minimizing water loss and 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 per cent of the increased agricultural demand by 2025 should be met by increasing productivity of water. The UN World Water Assessment Programme also calls for enhancement of crop water productivity to reduce demand for new supply sources or increasing water allocation to agriculture. The National Water Mission of the Government of India has set a target of increasing water use efficiency by 20 per cent as a part of **National Action Plan** on climate change. The Government of India also launched **PMKSY (Pradhan Mantri Krishi Sinchai Yojana)** with an aim to improve on farm water use efficiency to reduce wastage of water, enhance the adoption of precision irrigation ('more crop per drop') as well as enhance recharge of ground water acquifers and sustainable water conservation practices.

Examples of Best Practices:

In India, Jain Irrigation System Ltd. (JISL) is engaged in working in 'drip and sprinkler' irrigation, technology right from 1990s. Their experiment in rice production with drip irrigation has shown many economic benefits such as up to 40 per cent enhancement of rice yield, up to 70 per cent water savings, up to 50 per cent energy conservation, up to 80 per cent water and fertilizer use efficiency, soil health protection. In addition, there are health improvement of farm land 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. Similar results have been witnessed in the case of production of wheat crop with micro irrigation, precision farming for sugarcane, cotton production with drip irrigation, etc. Over the years, the JISL has introduced many steps for promoting 'More Crop Per Drop' measures.

Conclusion:

Efficient water use in agricultural sector is a challenging task in Indian context as stakeholders involved are too many. The participation of such stakeholders in this effort would require collaboration with governments, civil societies, corporate bodies, financial institutions and others. There is a need for change of mindset of the stakeholders as well. There is also a need to have an integrated solution for irrigation system such as introducing micro irrigation systems (for example 'drip and sprinklers'), application of information technology, use of sensor based water conveyance and application to fields, introducing solar pumping techniques and adopting other water conservation interventions (such as ground water recharge). Zero tillage technology[2] preserves moisture in the soil, and use of laser[3] leveling technology and has the potential to save irrigation water. There are good practices in India on the subject, but these should be scaled up. Current efforts of the governments are in the right directions.

Footnotes:

1. NCIWRD is National Commission on Integrated Water Resource Development
2. Zero tillage technology allows a farmer to lay seeds in the ground at a required depth with minimal disturbance of soil structure. Specially designed farm machinery eliminates the need for plowing and minimizes the tillage required for planting.
3. In agriculture, laser can guide workers to properly contour land for planting or prepare it for irrigation of major crops. This system cuts the soil preparation time of large land areas substantially compared to conventional method.

(The author is Former Secretary, Ministry of Water Resources, Govt. of India and Distinguished Fellow and Director, Water Resources and Forestry Division, TERI, New Delhi Email: SK.Sarkar@teri.res.in)

India Water Week - 2017

The Fifth India Water Week 2017 was inaugurated by the Hon'ble President of India, Shri Ram Nath Kovind on October 10, 2017 in New Delhi. This annual policy and technology showcase event is organised by the Ministry of Water Resources, River Development & Ganga Rejuvenation, Government of India. It is an annual forum where the Ministry of Water Resources, RD&GR, Government of India discusses, talks, strategizes with eminent stakeholders through seminars, exhibitions and sessions to build public awareness, to get support to implement key strategies for conservation, preservation and optimum use of available water.

While speaking at the inauguration of the event, the Hon'ble President said that currently, 80 per cent of water in India is used by agriculture and only 15 per cent by industry. In the coming years, this ratio will change. The total demand for water will also rise. Efficiency of water use and reuse, therefore, has to be built into the blueprint of industrial projects. Business and industry also need to be a part of the solution. He also said that water is essential to life. It is fundamental to the economy and to ecology – and to human equity. The issue of water is becoming still more critical in view of climate change and related environmental concerns. Better and more efficient use of water is a challenge for Indian agriculture and industry alike. It requires us to set new benchmarks in both our villages and in the cities we build. He said that, 40 billion litres of waste water is produced every dayin urban India. It is vital to adopt technology to reduce the toxic content of this water, and to deploy it for irrigation and other purposes. This has to be part of any urban planning programme.

The President urged a water management approach that is localised. He stated that it should empower village and neighbourhood communities and build their capacity to manage, allocate and value their water resources. Any 21st century water policy must factor in the concept of the value of water. It must encourage all stakeholders, including communities, to expand their minds – and to graduate from allocating a quantum of water to allocating a quantum of benefits. The government has prepared a strategic plan for ensuring drinking water supply in all rural areas by 2022, when India complete 75 years of Independence. By that year, the goal is to cover 90 per cent of rural households with piped water supply. We cannot fail. The deliberations of this conference have to ensure that we do not fail.

The event witnessed the participation in the discussions by various international delegates from the European Union countries, as well as their Indian counterparts. Also present were Union Ministers of the concerned Ministries.

The President, Shri Ram Nath Kovind lighting the lamp to inaugurate the India Water Week- 2017, in New Delhi on October 10, 2017. Also seen are Union Minister for Road Transport & Highways, Shipping and Water Resources, River Development & Ganga Rejuvenation, Shri Nitin Gadkari; the Union Minister for Drinking Water & Sanitation, Sushri Uma Bharti; the Minister of State for Parliamentary Affairs, Water Resources, River Development and Ganga Rejuvenation, Shri Arjun Ram Meghwal and the Minister of State for Human Resource Development and Water Resources, River Development and Ganga Rejuvenation, Dr. Satya Pal Singh.

PRADHAN MANTRI KRISHI SINCHAYEE YOJANA TOWARDS DOUBLING FARMERS' INCOME

Bharat Sharma

Prime Minister of India while talking about income of farmers in a Kisan Rally in Bareilly on 28th February 2016 stated that it is his dream to see farmers double their income by 2022 when the country completes 75 years of its independence. This will require an annual growth rate of 10.4 per cent for the next 7 years- a really daunting task. Important factors for achieving such a high growth shall include significant improvements in crop and livestock productivity, achieving higher resource use efficiency to lower the cost of production, increasing cropping intensity from the present level of 140 to 153 per cent and increasing area under high value crops from 16.75 to 26.4 Mha.

Most farmers are of the view that "Without water, nothing else matters!" Even as early as in 371 BC, Kautilya in *Arthashastra* advised "Agriculture cannot be made solely dependent on rains which amounts to gambling with nature". After about 2,400 years of civilisation since then and 70 years of planned development since independence, only about 45 per cent of cultivated lands of India are covered under assured irrigation. Importance of irrigation for higher and assured levels of production are well documented. District level data show that per ha productivity of all crops taken together was 1.6 times higher under largely irrigated conditions as compared to under largely rainfed conditions during biennium 2011-12. Though India is now self-sufficient in food production, 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. Enhancing access to irrigation and technological advancement are the most potent instruments to raise agricultural productivity. With availability of irrigation it is possible to enhance the cropping intensity known as 'vertical intensification'. Presently, 76 per cent of the agricultural land in the country remains unused for half of the productive period due to lack of access to meet the crop water requirement. Even in irrigated areas, adequate and affordable irrigation is not available throughout the year. Once assured irrigation is available, diversification to high value crops has the potential to raise the farmers' income. As per the data of NITI Aayog, shifting one hectare area from staple crops to high value crops like fruits, vegetables, floriculture, commercial crops etc. has the potential to increase gross returns upto Rs. 101,608/ha as compared to Rs. 41,169/ha for staple crops- an increase of 2.47 times.

Low and volatile growth in agricultural production is a serious concern and affects farmers' incomes. NSSO data for year 2011-12 reveals that more than one-fifth of rural households with employment in agriculture as their principal occupation were having income less than the poverty line and in some states like Jharkhand, 45.3 per cent of farm households were under poverty. The past green revolution technologies are input intensive and have not helped the entire agriscape of India. Additionally, average size of the operational holding is declining with 67 per cent as marginal farmers, there is a 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. The government has noticed a persistent distress among agrarian society and is eager to devise an effective mitigation policy.

Prime Minister of India while talking about income of farmers in a Kisan Rally in Bareilly on 28th February 2016 stated that it is his dream to see farmers double their income by 2022 when the country completes 75 years of its independence. This will require an annual growth rate of 10.4 per cent for the next 7 years- a really daunting task. Important factors for achieving such a high growth shall include significant improvements in crop and livestock productivity, achieving higher resource use efficiency to lower the cost of production, increasing cropping intensity from the present level

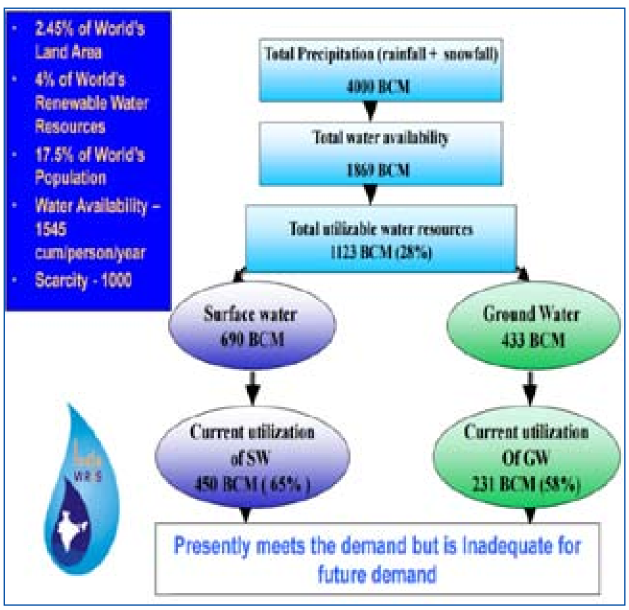


Fig. 1: Water Resources Scenario-India

of 140 to 153 per cent and increasing area under high value crops from 16.75 to 26.4 Mha. Coverage of agricultural farms under irrigation shall play a pivotal role to implement all these interventions and estimates show that gross irrigated area needs to be increased from the present level of 92.6 Mha to 110.4 Mha in 2022- an increase of 2.5 Mha per annum. For achieving such an unprecedented growth in irrigation coverage the 'business as usual' shall not suffice and some innovative schemes with good convergence and much larger allocation of funds need to be put in place.

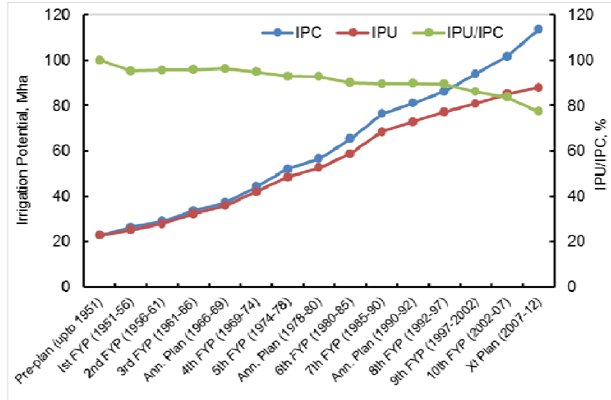
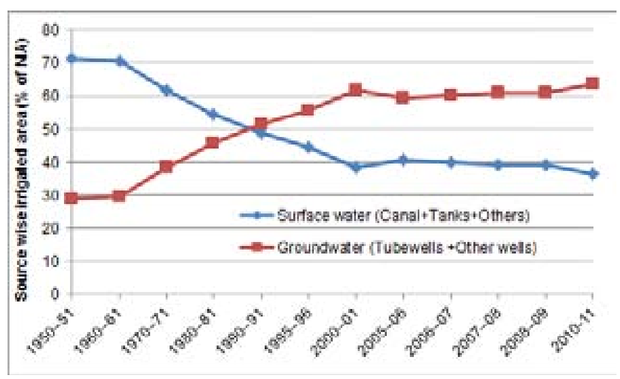


Fig. 2: Increasing gap between the irrigation potential created (IPC) and irrigation potential utilised (IPU) in India- present utilisation is only about 80%

Prime Minister Krishi Sinchayee Yojana (PMKSY):

In spite of India being blessed with ample water resources at the national level (Fig. 1), the present Indian irrigation is besieged with several problems including a widening gap between irrigation potential created (IPC) and irrigation potential utilised (Fig. 2), high dependence on groundwater irrigation (Fig. 3) leading to and over-exploitation of groundwater resources and declining water tables in large parts, poor development of water resources and rural electrification and seasonal flooding in the eastern region, low water-use efficiency/ water



Assessed units	**6584**
Over-Exploited	**1034 (16%)**
Critical	253 (4%)
Semi-Critical	681 (10%)
Safe	4520 (69%)
Saline	96 (1%)

Fig.3: Groundwater is now the major source of irrigation (> 60%) leading to over-exploitation of the resources especially in the intensive irrigated regions.

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.

With the objective of addressing several of the above stated concerns in the farm irrigation sector and also to facilitate to double the farmers income by 2022, an ambitious scheme of '***Pradhan Mantri Krishi Sinchayee Yojana'*** was developed with the twin objectives of *"Har Khet ko Pani-* providing irrigation to each farm" and *"Per drop more crop-* improving water productivity" and launched by the Government of India. Salient features of the schemes are illustrated below (Fig. 4).

Speedy execution of the river linking project, at least one new water conservation structure per village, speedy completion of the pending irrigation projects and massive expansion of micro-irrigation systems to achieve 'more crop per drop' were advanced as the instruments to achieve the vision. Profile and main components of PMKSY are given in Table 1.

Table 1: Components and Allocation for PMKSY (2016-17)

PMKSY Compo-nents	Ministry/ Depart-ment	Physical Target (lakh ha)		Indicative out-lay (Rs. crore)	
		2015-20	**2015-16**	**2015-20**	**2015-16**
Acceler-ated Irrigation Benefit Program	MoWR-RD&GR	7.5	1.2	11,060	1000
Har Khet ko Pani		21.0	2.8	9050	1000
Per Drop more Crop	DoA&C	100.0	5.0	16300	1800
Watershed develop-ment	DoLR	11.5	4.4	13590	1500
Total				**50,000**	**5300**

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.*

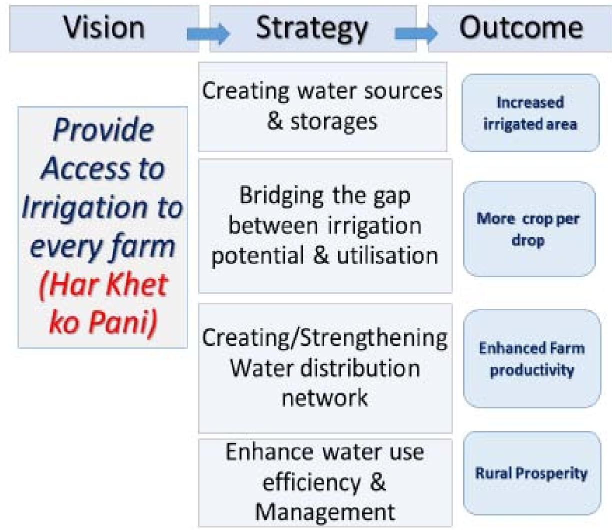


Fig. 4: An illustration of the vision, strategy and expected outcome of the PMKSY

- Creation of new water sources through minor irrigation schemes, repair, restoration and renovation of water bodies, and additional rain water harvesting structures under *Har Khet ko Pani.*
- Efficient water conveyance and precision water application devices like drips, sprinklers, pivots, 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. Implementation of the program has been quite ambitious where (i) sensitisation workshops were organised for IAS and IFS officers about the PMKSY and guidance on preparation of the "District Irrigation Plan", (ii) Knowledge partnerships were developed with ICAR, NIRD, CWC/NWDA and other NGOs for capacity building and experiential learning in different regions of India, (iii) Ministry of Agriculture developed and shared the format for developing the District Irrigation Plan (DIP)- which is the heart of the program. These DIPs shall be discussed at the state and central level coordination committee for review and clearance, (iv) A total of 99 ongoing AIBP projects have been identified for completion upto March 2020 phase, (v) Funding for the program shall be made available through NABARD, an additional fund of Rs. 500 crore has also been marked for micro irrigation.

The program is regularly reviewed by the PMO and NITI Ayog about its progress and during the last review on March 30, 2017, Prime Minister called for synergy between various government departments, *Krishi Vigyan Kendras* and agricultural universities to work out efficient cropping patterns and water use mechanisms in the command areas of these projects. He exhorted the officials to work with a comprehensive and holistic vision for the PMKSY.He also called for using the latest available technology, including space applications, to monitor the progress of irrigation projects.

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 a number of factors including (i) lukewarm interest at the district and state level, (ii) insufficient capacity at the district to develop an innovative and cost-effective District Irrigation Plan which really addresses the issues of the district (iii) lack of synergy and convergence between different line development departments, (iv) aspirations of the district/ state in fund allocation are much higher than the actual funds available under the scheme.

It is therefore, essential that the state and the districts select the most innovative and promising interventions which can deliver the expected outcomes in the in the next 5-7 years' time when Prime Minister has promised to Double the Farmer Income. Research by International Water Management Institute and several other stakeholders have identified the following promising interventions for inclusion in DIPs of the PMKSY:

Proposed Interventions for Successful Implementation of PMKSY and Doubling Farmers Income:

i. Support for development of groundwater and lift-irrigation schemes. Targeted support to irrigation deprived farm households to construct wells/ tubewells.

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

iii. Support to Solar Power Irrigators Cooperatives especially in the non-grid areas with shallow water tables.

iv. Support to Micro-Irrigation to promote speedy installation of drips and sprinklers especially in the water stressed areas and areas underlain with poor quality groundwater.

v. Closing the gap between IPC-IPU in the existing major and medium irrigation schemes. Desilting of minors and water courses, allocation of irrigation through scientific roasters, and urgent completion of the deferred maintenance.

vi. Supporting conversion to underground piped conveyance network to reduce the water losses and delivering uniform supplies.

vii. Conjunctive management of tanks and groundwater systems through regular desilting of tanks, reducing encroachments, buried supply channels etc.- emulate Mission Kakatiya of Telangana.

viii. Encourage groundwater harvesting and recharge, recharge shafts, recharge tubewells, infiltration wells and percolation tanks, tame the seasonal floods for recharge through schemes like "Underground taming of Floods for Irrigation."

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

x. Encourage peri-urban wastewater irrigation for farm forestry, fodder, vegetable and floriculture cultivation.

xi. In hilly areas of Uttarakhand, Himachal Pradesh, Jammu and Kashmir, Sikkim and north-east states, special emphasis is given on the rejuvenation of the springs- emulate 'Dhara Vikas' program of the Sikkim government.

xii. Support revival of traditional hill water management systems and proven practices like Multiple water use systems (MUS) combining domestic and small agricultural/livestock water use, *Jalkunds* in high rainfall areas, bamboo drip system, Jabo system and other practices involving indigenous knowledge.

xiii. 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.

xiv. Create synergies and convergence with the already on-going schemes like MGNREGA, National Food Security Mission, *Rashtriya Krishi Vikas Yojana*, Bringing Green Revolution to Eastern India, and National Mission on Micro Irrigation.

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IRRIGATION SYSTEMS IN INDIA

Vasudev Meena

In India, agriculture is mainly dependent on rainfall. The rainfall is generally unpredictable in its incidence and variable in amount. The distribution of water in India is, therefore, very uneven. The rainfall in the country is concentrated usually during four months in a year when there is excess water which flows down unutilized, while in other seasons, there is an acute shortage of water. India has large water resources, great rivers systems and vast thirsty tracts of land and is thus designed, so to say by nature for the development of irrigation.

Irrigation is a technique of supplying water to the dry land as a supplementation of rain water. It is mainly aimed for farming. There are various types of systems of irrigation practices in different parts of India. Irrigation in India is carried on through wells, tanks, canals, perennial canal and multipurpose river valley projects. The irrigation engineer should be acquainted with the type of soil moisture, quality of irrigation water, frequency of irrigation for the proper implementation of irrigation system.

Being an agriculture dependent country, irrigation is the backbone of India. India is a vast country with a diverse biodiversity i.e. topography, climate and vegetation. The total of cultivable area in the country is about 185 million hectares. At present, about 172 million hectares are under cultivation. Seventy per cent of India's vast population depends upon agriculture directly for their living, and therefore, agriculture has always been and promises to remain the main industry of India in predictable future also. In India, agriculture is mainly dependent on rainfall. The rainfall is generally unpredictable in its incidence and variable in amount. The distribution of water in India is, therefore, very uneven. The rainfall in the country is concentrated usually during four months in a year when there is excess water which flows down unutilized, while in other seasons, there is an acute shortage of water. India has large water resources, great rivers systems and vast thirsty tracts of land and is thus designed, so to say by nature for the development of irrigation.

India's irrigation is mostly groundwater well based. At 39 million hectares (67 per cent 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 million ha from surface water and 35 million ha from ground water. The gross cropped area is expected to increase to about 200 million ha during the next two decades due to introduction of multiple cropping and land reclamation. Among the agricultural inputs which include seeds, fertilizers, plant protection, machinery and credit, irrigation assumes an important place. Irrigation means watering the fields by any means other than rain or is the artificial application of water to the land or soil. It is the replacement or supplementation of

rainwater with another source of water. It is used in dry areas and during periods of inadequate rainfall.

Need for Irrigation:

- India is a big country and stands next to China when we talk about population and 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. By means of irrigation we can check both the problems.
- 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 rapid, so, artificial irrigation is necessary for ample supply of water and also to prevent water scarcity in the 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 per cent is shared by tube wells followed by Canals and wells.

Since 1950-51, the government had given considerable importance to the development of command area under canals. In 1950-51, the Canal irrigated area was 8.3 million hectares and it currently stands at 17 million hectares. Despite that, the relative importance of Canals has come down from 40 per cent in 1951 to 26 per cent in 2010-11. On the other hand, the well and tube well accounted for 29 per cent total irrigated area and now they share 64 per cent of the total irrigated area.

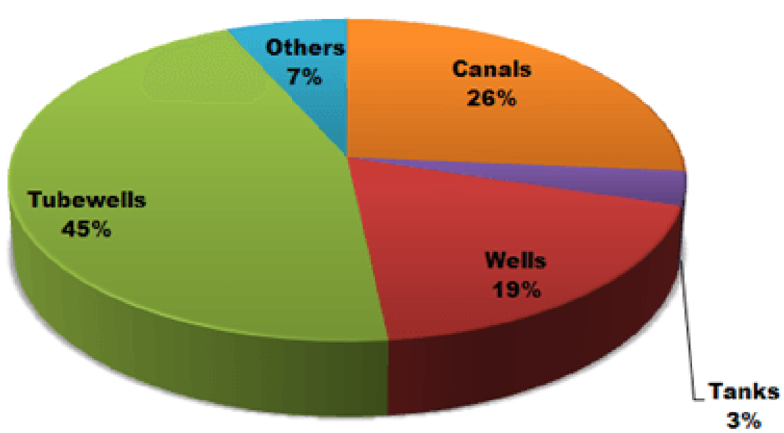

Fig.1: Sources of Irrigation in India 2010-11

Types of Irrigation System:

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

1. **Tank Water Irrigation System:** It is prevalent in the uneven and relatively rocky plateau of Peninsular India. Tanks are commonly used in Deccan Plateau, Andhra Pradesh, Karnataka, Tamil Nadu, Eastern Madhya Pradesh, Chhattisgarh, Orissa and Maharashtra. About 8 per cent of total irrigated area is irrigated by tanks. There are about 5 lakh big and 50 lakh small tanks irrigating over 25.24 lakh hectares of agricultural land. Most of the tanks are small in size and built by individuals or group of farmers by raising bunds across seasonal streams.

- Most of the tanks are natural and do not involve heavy cost for their construction. Even an individual farmer can have his own tank.
- Tanks are generally constructed on rocky bed and have longer life span.
- In many tanks, fishing is also carried on. This supplements both the food resources and income of the farmer.

But there are some drawbacks: Tanks covers a large area of cultivable land. Evaporation of water is rapid due to large expanse of shallow water of tanks, do not ensure perennial supply of water. Moreover, lifting of water from tanks and carrying it to the fields is a strenuous and costly exercise which discourages the use of tanks as a source of irrigation.

2. **Well Water Irrigation System.** It is more widespread in plains, coasts and some regions of peninsular India. It is less costly and more flexible as water can be drawn whenever needed and 'evaporation loss' is minimized and no fear of "over irrigation".

- There were about 5 million wells in 1950-51 and their number has now increased to about 12 million. Well irrigation accounts for more than 60 per cent of the net irrigated area in the country against 29.2 per cent of canal and only 4.6 per cent of tank irrigation. It accounted 59.78 lakh hectares in 1950-51 which rose to about 332.77 lakh hectares in 2000-01 thereby registering more than fivefold increase in well irrigation.

- Uttar Pradesh has the largest area under well irrigation which accounts for about 28 per cent of the well irrigated area of India. This is followed by Rajasthan (10 per cent), Punjab (8.65 per cent), Madhya Pradesh (8 per cent), Gujarat (7.3 per cent), Bihar, Andhra Pradesh and Tamil Nadu, etc.
- In Gujarat, about 82 per cent of the net irrigated area is under well irrigation. The other states where well irrigation plays a significant role are Punjab (80 per cent), Uttar Pradesh (74 per cent), Rajasthan (71 per cent), Maharashtra (65 per cent), Madhya Pradesh (64 per cent) and West Bengal (60 per cent)
- Uttar Pradesh, Rajasthan, Punjab, Madhya Pradesh, Gujarat, Bihar and Andhra Pradesh account for three-fourths of the total well irrigated area of India.

Table 1: Major Irrigation Projects in India

S. No.	Name of the project	River	Beneficiary states
1	Bhakra Nangal Project	Satluj	Punjab, HP, Haryana & Rajasthan
2	Damodar Valley project	Damodar	Bihar & West Bengal
3	Hirakund Dam	Mahanadi	Orissa
4	Thungbhdra Project	Thungbhadra	AP & Karnataka
5	Nagarjuna Sagar Project	Krishna	AP
6	Kosi Project	Kosi	Bihar
7	Farakka Project	Ganga Bhagirathi	West Bengal
8	Gandak project	Gandak	Bihar, UP & Nepal
9	Beas Project	Beas	Rajasthan & Punjab
10	Rajasthan Canal	Satluj	Rajasthan, Punjab & Haryana
11	Chambal Project	Chambal	Madhya Pradesh & Rajasthan
12	Ukai Project	Tapti	Gujarat
13	Tawa Project	Narmada	Madhya Pradesh
14	Sri Ram Sagar Project	Godavari	Andhra Pradesh
15	Malaprabha Project	Malprabha	Karnataka
16	Mahi Project	Mahi	Gujarat
17	Mahanandi	Mahanadi	Orissa
18	Indukki Project	Periyar	Kerala
19	Koyna Project	Koyna	Maharastra
20	Upper Krishna Project	Krishna	Karnataka
21	Ram ganga project	Ram ganga	Uttar Pradesh
22	Tehri dam	Bhilan ganga & Bhagirath	Uttar Pradesh
23	Narmada Sagar	Narmada	MP, Rajasthan, Gujarat & Maharastra
24	Massanjore (Canada) Dam	Mayurakashi	West Bengal

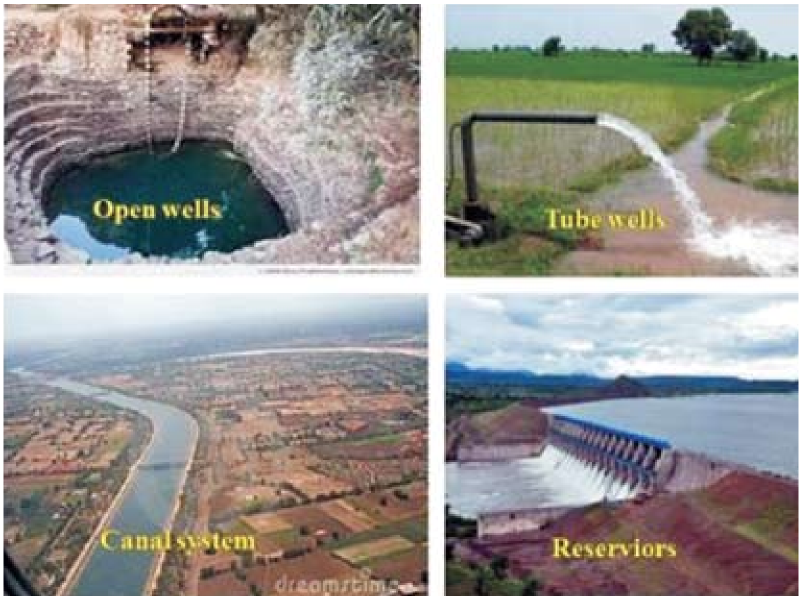

Fig 2: Types of Irrigation Systems

Wells are of two types:

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

B. **Tube-wells:** Tube wells are deep, more suitable and have the capacity to draw a large volume of water. Such type of well always has water irrespective of time. A deep tube well worked by electricity, can irrigate a much larger area (about 400 hectares) than a surface well (1/2 hectares). It has increased in recent years. Tube-wells are also used for irrigation purposes. Tube wells can be installed and used near agricultural land where ground water is readily available.

These are mostly used in U.P., Haryana, Punjab, Bihar and Gujarat. 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: Canal irrigation is playing a vital role in Indian agriculture because these are the main source of irrigation in India. It covers near about 42 per cent of total irrigated land. The net area under canal irrigation is about 15.8 million hectares. In many places during the rainy season, there is flood in the rivers. The flood water is carried to the field through canals. These canals are found in W.B., Bihar, Orissa, etc. They supply water only when there is flood in the rivers, and therefore, are of no use during the dry season when water is required most.

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 canals of Uttar Pradesh are upper and lower Ganga Canal, Agra and Sharda Canal and 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: The perennial 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". From these reservoirs, water can be supplied to the fields whenever there is demand for it. So this system of irrigation ensures supply of water in all seasons. This system is greatly adopted in Tamil Nadu, Andhra Pradesh, and Karnataka, etc. Even in Northern India, this type of perennial canal is found mostly in Punjab, U.P., and Tamil Nadu for storing water. From these reservoirs, water is carried to the fields through canals.

In Punjab, the upper Bari Doab canal connecting the Ravi and the Beas and Sirhind (from the Sutlej) canal is famous. In U.P., the Upper Ganga and the Lower Ganga canals, Agra and Sarda canals, etc. are important. In Tamil Nadu, most important are the Buckingham canal and the Periyar canal. In many places, rain-water harvesting systems are installed and water is stored in large artificial reservoirs to be used for agricultural purposes.

5. **Multipurpose River Valley Projects:** In recent years, multi-purpose river valley projects are helping in irrigation and growth of agriculture. The most important river valley projects and their beneficiary states are:

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WATERSHED DEVELOPMENT IN INDIA

V. Srinivas

The Neeranchal Project with an outlay of Rs. 2142 crores sought to translate into better implementation the outcomes of Pradhan Mantri Krishi Sinchayi Yojana (PMKSY). Neeranchal 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. Neeranchal incorporated the best practices of watershed management in India. It emphasized the need to improve knowledge sharing in support of project preparation, publish draft reports on progress achieved, collate best practices in key areas, conducting knowledge fairs and workshops.

The rainfed areas of India are amongst the most challenging for the sustenance of agrarian economy. They are almost entirely single cropped areas with scanty rainfall, prone to frequent droughts, soil erosion, characterized by fragile pasture lands necessitating large-scale cattle migration, depleting water tables, low employment opportunities and chronic poverty levels. It was to address these very challenging agrarian economies that the watershed development and soil conservation programs were formulated.

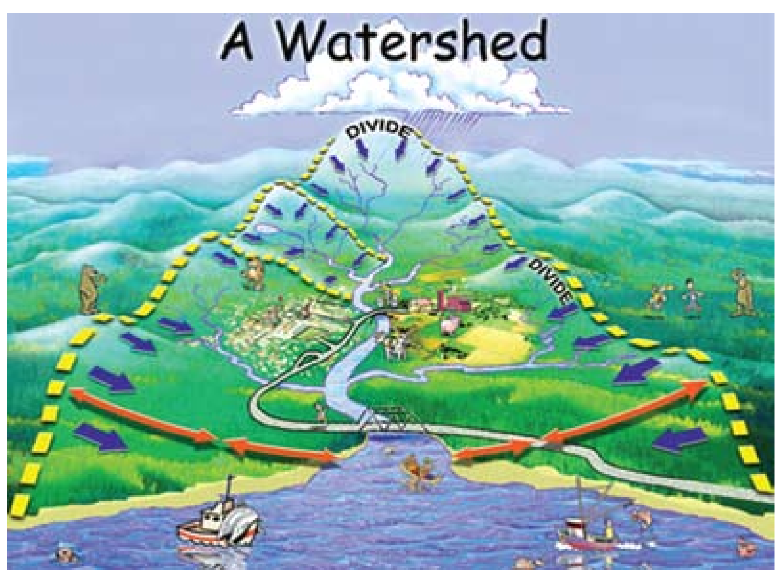
Watershed Development Initiatives in the 1990s:

In the 1990s, watershed based efforts at resource management had great appeal amongst academics, policy makers, environmentalists and had spawned considerable activity on a pan India basis. India's policy makers held the view that the watershed approach was inherently sound and filled a major gap in our land and water development programs. From the WARASA guidelines in 1990-91 to the 2015 NEERANCHAL guidelines, integrated watershed management program has remained a flagship program for government in its efforts for drought moderation. The program has developed into a huge people's movement based on pragmatism and effective regional organizations.

The Government of India 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. Watershed development projects were considered feasible if the benefit cost analysis indicated that the benefits exceeded costs, or if each of the separate purposes of the project indicated benefits equal to costs. Watershed development works of drainage line treatment, farm ponds, use of vegetative technology for soil conservation were undertaken in areas where maximum benefits could be realized, with the objective of achieving the highest cost benefit ratio.

DPAP and DDP:

Dr. C.H. Hanumantha Rao chaired a technical committee on Drought Prone Areas Program



(DPAP) and the Desert Development Program (DDP). He recommended these schemes be recast on a more participatory watershed development model to make them effective. He said that despite the fact that DPAP and DDP had been in operation for almost 2 decades, it was observed that the programs had not created a substantial impact. The drought conditions in the country were increasing and ecological degradation was taking place unabated especially in drought prone and desert areas. The success stories at Ralegaon Sidhi and Adgaon in Maharashtra, Kabbalnala and Mittemari in Karnatak, Jhabua in Madhya Pradesh presented a case that drought can be beaten with concerted efforts for development on watershed basis and active participation of local farmers willing to undergo sacrifices and share benefits. 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 the programs to mitigate the rigors of drought. They reiterated that harmonious management development and utilization of land, water and vegetation resources on watershed basis should be implemented with total participation of beneficiaries. The recommendations of the Technical Committee on DPAP and DDP resulted in comprehensive recasting of these schemes on watershed development basis.

NWDPRA:

The watershed movement was much more than an organized effort of Government. It entailed complex issues of coordination as India entered the watershed collaborative era giving greater access to citizens and local organizations in decision-making and holistic management principles. The National Watershed Development Program for Rainfed Areas (NWDPRA) recognized that sustainability was possible only through people's participation and implementation should be through a participatory model. It further recognized that capacity building was needed for all stakeholders. Institutional development should start from the planning stage and continue to project implementation and maintenance stages. Exposure visits were necessary for increasing awareness levels and interaction. The role of women was seen as crucial from planning to implementation. Monitoring and evaluation from an independent agency was necessary. Conventional watershed activities had little potential for raising incomes of farmers. Hence the integrated management of watersheds broadened the scope of projects to include subsidiary income generating activities, agricultural/ non-agricultural activities.

The objectives of the NWDPRA were (a) conservation, development and sustainable management of watersheds including their use, (b) enhancement of agricultural productivity and production, (c) restoration of ecological balance in the degraded and fragile rainfed ecosystems by greening the areas through appropriate mix of shrubs, trees and grasses, (d) reduction in regional disparity between irrigated and rainfed areas and (e) creation of sustainable employment opportunities. The focus was on the 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, direct funding and empowerment of village communities and building indigenous innovations. The Watershed development was undertaken in a phased manner, with an awareness generation phase, a capacity building phase and a project implementation phase followed by sustainable management phase. The District level project implementation agency was supported by village level watershed development teams and watershed 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. The project sought to adopt institutional arrangements to facilitate inter-agency coordination in watershed planning and implementation, and to ensure full participation of watershed land users in the development and management of common properties.

Following completion, the World Bank assessment of the project outcomes was satisfactory. All project objectives were substantially achieved. The program of land treatments were either substantially achieved or even exceeded and were generally of good quality and developments created positive impacts on the conservation and restoration of natural resources and increased agricultural production. The project also substantially improved the collective capability of government agencies to implement programs of watershed development. It helped achieve substantial involvement and commitment of local communities in planning, managing and maintaining improvements of communal and individual natural resources and assets.

The key lessons learnt were:

- Initiatives that benefitted project implementation included (i) regular supervision and constructive approach, (ii) flexibility to respond to the needs and priorities of beneficiaries, (iii) emphasis on beneficiary participation and strictly following cost sharing norms, (iv) regular training/ exposure of the staff to methodologies and experiences in watershed development, (v) maintenance of staff continuity; (vi) introduction of innovative ways to facilitate inter state exchange of experiences.
- Potential improvements that should be considered in the design of future watershed development projects included the need to assign sufficient time and emphasis in the beginning of projects to governmental and community joint planning (defining, location and sequencing project interventions and assigning responsibility) in watershed development. This was necessary to ensure direct emphasis on women's needs, aspirations and involvement in watershed development, and give more emphasis to policy and action plans concerning macro level management of natural resources, particularly issues associated with over grazing and over utilization of natural fodder and forest resources.

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. This was seen at the district level and also at the field levels. There were coordination difficulties between transient actors pursuing departmental agendas. The sharp focus needed to implement watershed programs was often absent because the officials had many other competing priorities. The HARIYALI guidelines required to be recast for effective implementation. 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 the watershed programs. This National Authority was to be responsible for bringing prosperity to the watershed regions through the sustainable development of natural resource base. The Committee also recommended that watershed development works be taken up over a 8 year program period divided into 3 phases – phase I for 2 years to be termed as the preparatory phase of the program, phase II for 4 years to be termed as the resource augmentation and institution building phase and phase III for 2 years to be termed as the sustainable livelihoods and productivity enhancement phase. The Technical Committee formulated the Neeranchal guidelines for watershed development to replace the Hariyali guidelines.

NEERANCHAL:

In 2015, Government of India approved the World Bank assisted project "Neeranchal" for implementation. The Neeranchal 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 and have quantifiable results. Further 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.

The Neeranchal Project with an outlay of Rs. 2142 crores sought to translate into better implementation the outcomes of Pradhan Mantri Krishi Sinchayi Yojana (PMKSY). Neeranchal 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. Neeranchal incorporated the best practices of watershed management in India. It emphasized the need to improve knowledge sharing in support of project preparation, publish draft reports on progress achieved, collate best practices in key areas, conducting knowledge fairs and workshops. 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 Department of Agriculture and Cooperation 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. The NRAA serves as a knowledge platform and connects research and academic institutions and implementing agencies. It also focuses on livelihood opportunities for the landless and marginal farmers who constitute a large majority of the rainfed area population. NRAA facilitates skill and knowledge development of farmers and enables openness and ability to adopt improved technologies and management practices for crop production, animal husbandry, horticulture, agro-forestry and farm resources linked enterprises. The strategy for achieving sustainable and comprehensive development of the rainfed system in the country is guided by the principles of integrated farming systems, watershed management and resilience in the context of climate change.

The long-term measures for drought mitigation suggested by the NRAA are in-situ conservation of rain water, contour cultivation, sowing on ridges or raised beds especially in black soils can raise productivity by 15-20 per cent. Seed replacement rate of pulses, oilseeds and cereals with latest improved varieties would enable enhanced yields. Breed improvement of cattle population along with castration of scrub bulls has been identified as a major intervention. The NRAA has also recommended longer credit cycles in rainfed areas in cases of weather contingency.

Conclusion:

To conclude, it can be said that India's watershed development programs in the collaborative era have witnessed several success stories. The country has established an apex authority the NRAA for technical assistance. The program guidelines have been made highly participatory and adequate time has been given for implementation. The government has provided adequate resources and manpower for effective implementation. In the successful implementation of the Neeranchal program lies the future of millions of rainfed farmers of India.

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FLOODS AND DROUGHTS IN INDIA: CAUSES AND SOLUTIONS

Chetan Pandit

Floods can't be entirely prevented. The 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.

On an average, every year India gets 4,000 billion cubic meters of water mostly through rainfall and some snowfall. However, this is the average, over a large number of years. In any given year, the rainfall, and hence the river flow, may vary from this average, on the lower side, or on the higher side. Such rainfall instances, very low or very high, are called hydrologic extremes. Floods and droughts, both are a result of hydrologic extremes. This short article explains the phenomenon of floods, and droughts, why these occur, and how to manage them.

Floods:

The term 'flood' is commonly used to describe any inundation by water. But there are two distinct mechanisms that can cause inundation. A rainfall takes place somewhere in the upstream catchment, and consequent high flow in the river may spill out in to the habitation areas some where 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 the city/ village. This is called drainage congestion. The inundation that takes place in many parts of Uttar Pradesh, Bihar, and Assam every year, is flood. The inundation that took place in Mumbai in July 2005, or September 2017, was drainage congestion.

In India, 33.5 m.Ha (million Hectares) of area is flood prone, and out of this, on an average, some or 7.5 m.Ha is affected by floods every year. The floods are most common in Ganga and Brahmaputra river basins.

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 river 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 water bursts, and the accumulated water flows out in a short time, causing a flood.

- **Breach of Embankments.** Embankments are constructed along both banks of the 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 a flood.

Whatever may be the cause, a flood causes a huge damage to property and also life – human and farm animals, destroys standing crops, deposits sand in the farms and renders them unsuitable for cultivation, destroys buildings and also destroys roads/ railway lines/ bridges/ communication links. A flood also destroys drinking water sources and is often followed by an outbreak of water borne diseases.

Managing Floods:

Floods can't be entirely prevented. The 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.

Embankments are low bunds constructed along the river bank, to "contain" the river flow and prevent it from spilling in to the areas of human activity. Embankments are the fastest way of providing protection from a flood of specified severity, and can be constructed within one year. However, embankments need careful maintenance else these can breach. Also, embankments can increase the flood problem upstream and downstream.

A flood control reservoir stores the incoming flood water, and releases it slowly after the flood is over. Flood control reservoirs are the most reliable and long lasting protection from floods. Many such reservoirs have been constructed in India and have very successfully provided long term flood protection. Most famous examples being Hirakud dam on Mahanadi, and a series of dams in Damodar valley.

Flood forecasting doesn't prevent flood, but can prevent loss of life, and to some extent the loss of property. Flood plain zoning refers to restricting various activities in flood planes, depending on the risk assessment. Viz. an office may be built close to the river, where the flood risk is high, but hospital or school must be built farther away, where the risk is less.

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

Drainage Congestion:

Inundation in cities is usually due to the inability to drain out the rain water fast enough. Construction of buildings impedes the flow of water over the 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. Mumbai was inundated on 29th August 2017. And at the same time, the city of Houston in USA was also inundated, far worse than Mumbai, due to the same mechanism. It may sound harsh, but short duration inundation due to drainage congestion, is a problem the cities may have to live with.

What is Not A Solution:

We live in an era of self-proclaimed experts, and there is lot of misinformation doing the rounds, about what causes floods and how to manage them. Three of these needs to be addressed.

- Dams do not cause floods. Dams moderate floods. The extent of moderation depends on how full the reservoir was when the flood started. But the flood released over the dam spillway is invariably less than the flood that would have been, had there been no dam.
- Forests are not the solution to floods. Foliage of trees intercepts some rainfall; tree roots promote percolation; and trees act as impediment to water flow. But the impact of all this is perceptible only for small floods. For large devastating floods, the impact is insignificant.
- There is no such thing as 'our ancestors had learnt to live with the floods'. When the population was less, and the pressure on land resources was less, it was possible to simply live away from the river. Many villages are now located close to the river out of compulsion.

Droughts:

Like floods, droughts are also a hydrologic extreme. But drought neither have a clearly defined beginning, nor a clearly defined end. At times, it may not be even possible to say with certainty that a drought has set in. 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 and /or aquifers.
- **Agricultural** drought is when there is inadequate water supply to crops, and the crops start wilting.

About 153 mha area of the country is drought prone. Till about 1900, drought meant famine and widespread deaths. As many as 11 famines were recorded between 1769 and 1901 with an estimated 20 million deaths. However, now it is possible to transport large quantities of food grains to drought affected area, and to some extent also transport water, and the famine deaths are avoided. Nevertheless, drought brings severe distress to rural people even in this age.

When the rainfall is severely deficient, a normal crop can not be achieved. The objective should be to enable survival of the people and farm animals, till the next monsoons. Ground water can provide the minimum quantity of water required for such survival, provided it is wisely used when there is no drought. Unfortunately, that does not happen.

Ground water can be viewed as comprising two components. One, the annual recharge. Two, the water that has come to be stored in deeper aquifers, over a very large number of years. The ground water strategy should be to use every year only that water which is recharged every year, and keep the water in deeper aquifers as a reserve, for supplying minimum requirement during a drought year. This strategy will not completely avoid a drought, but will considerably reduce its impact. Unfortunately, there is no control on extraction of ground water, and not only the annual recharge but even the deeper aquifers are being pumped dry.

Inter Basin Water Transfer (IBWT):

The geographical area from which the rainfall accumulates and drains out through a river, is called its river basin. 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. The earliest plan to construct canals to link certain rivers, was in the year 1858 by Sir Arthur Cotton, a British engineer. However, the purpose of his plan was inland water transport, and not water distribution. Around the same time, railway as a means of transport became feasible, and his plan of interconnecting the rivers was set aside.

Around 1972, Dr. K L Rao, a former Minister for Irrigation, and also an accomplished river engineer, proposed a plan to transfer water from Ganga near Patna to Cauvery through a series of canals and pipelines. His plan was based on good engineering, but the cost was very high as compared to its benefits, and therefore, it was not taken up for construction.

In mid 1970s, Capt. Dinshaw J Dastur proposed another scheme comprising two very large canals, a 4200 km long canal in Himalayan area, and a 9300 km long canal in peninsular India, and two pipelines connecting these two canals, to connect some major rivers. Dastur's plan was well intentioned, its engineering concept was unsound. The 4200 and 9300 km long canals he envisaged were impossible to construct, so the question of cost or benefit did not arise.

In 1982, the Government of India set up National Water Development Agency (NWDA) to carry out the water surplus/ deficit studies for major river basins, and prepare a plan for inter basin water transfer. After about 18 years of work, around the year 2000, the NWDA made public the "National Perspective Plan for Inter Basin Water Transfer", (NPP) popularly known as river linking plan.

NWDA discarded the earlier ideas of one huge canal to link all the rivers, identified water surplus areas and water deficit areas, and proposed 30 different links to transfer water from surplus areas to deficit areas. This is the plan that the nation is now pursuing. For more details of this plan, the reader may visit the website of NWDA, www.nwda.gov.in. Following are the 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 Andhra Pradesh, Karnataka, Tamil Nadu, M.P., W.B., Bihar, U.P., Haryana, Rajasthan, Jharkhand, and Gujarat;
- Flood control in Ganga, Brahmaputra, Mahanadi and Godavari basins;
- Facilitate inland navigation;
- Development of fisheries;
- Infrastructure Development;
- Employment Generation;
- Improve aquatic environment by improving EFR, during lean season.

It needs to be pointed out that IBWT will provide flood control, not by transfer of excess water outside flood prone area, but by construction of many reservoirs, which are an integral part of the NPP. The reservoirs will reduce the flood peaks by 20 per cent to 30 per cent, but will not eliminate the flood problem entirely.

The main objective of the IBWT is to reduce regional imbalance in water availability. A stage has come where some areas have water but no land to irrigate, and some areas have land but no water. IBWT is not something new, or out-of-this-world idea. Many such schemes are already existing. The most notable are, Beas – Sutlej link, IGNP Canal which brings Sutlej water to Rajasthan, Sardar Sarovar main canal that takes Narmada water to Saurashtra, Periyar Vaigai link, etc.

Unfortunately, in India, any infrastructure project is opposed in the name of environment and rights. And the NPP for IBWT is also being opposed. In February 2012, the Hon'ble Supreme Court gave detailed directions for implementation of NPP. Some activists filed a review petition, but this was rejected by the Court. However, the environmental laws and procedures in India are very strict, and land acquisition is also a problem. Ken-Betwa is likely to be the first link to be taken up, and one hopes that more will follow soon.

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

Anjani Kumar and Ranjan Kumar Mohanta

With half the cultivable land in the country still being rain-fed, there is mammoth potential for promoting micro-irrigation in India. To change this situation, there is need of strong political will, a dedicated team of extension personnel to create awareness among farmers about the importance of micro-irrigation and available Govt. Schemes along with a better and efficient administration delivering the inputs.

Indian population is expected to reach 1.6 billion by 2050, which along with a large number of livestock needs to be supported from the available resources. To achieve food security of this large population, increase in productivity is the only option as the land devoted for agriculture sector is limited. This agrarian sector is the principal source of livelihood for over 60 per cent of rural households. As per United Nations Food and Agriculture Organization (UNFAO, 2011), irrigation and livestock segments use 91 per cent of water withdrawal in India. About a third of the water withdrawal comes from groundwater. Ground water level is depleting very fast due to its use in irrigation along with rural and urban water supplies. Presently, about 54 per cent of India suffers from water stress. As recharging most of this withdrawn groundwater takes a long time and the groundwater exploited from greater depth cannot be recharged by rainfall, there is an urgent need of sustainable and judicious use of water resources.

Introduction:

Water is applied to crops externally through irrigation, in order to sustain crop production and productivity. 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. India has a net irrigated area of 65.3 million hectares out of 142 million hectares under agriculture. Most common method of irrigation under Indian agriculture is Surface irrigation, but its water use efficiency is low (Table 1). The irrigation methods having greater irrigation efficiency are different methods of micro-irrigation like drip and sprinkler irrigation. Drip irrigation and Sprinkler irrigation are the usual micro-irrigation systems followed.

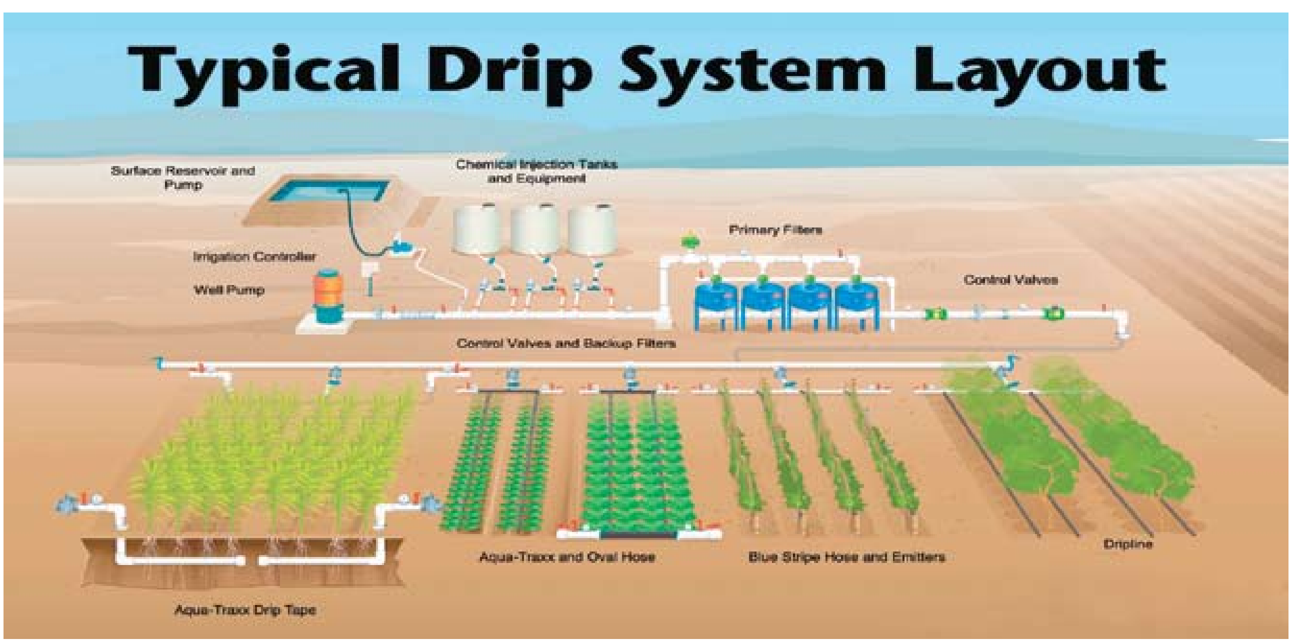


Table 1: Water Use Efficiency (%) Under Different Irrigation Systems

	Surface irrigation	Sprinkler irrigation	Drip irrigation
Conveyance efficiency (%)	50-70	Not applicable	Not applicable
Application efficiency (%)	40-70	60-80	90
Surface water moisture evaporation (%)	30-40	30-40	20-25
Overall efficiency (%)	30-35	50-70	80-90

Drip irrigation system irrigates the root zone of the crop, not the whole surface. It provides a continuous supply of water throughout the day by releasing frequent, but small quantities of water continuously unlike surface irrigation where feast and famine cycles affect growth and yield parameters. In sprinkler irrigation, water is distributed through a system of pipes, is sprayed on the crops and falls as smaller water drops.

Micro-irrigation: Way to 'More Crop Per Drop'

Micro-irrigation helps in reduction of input consumption and increases the productivity of the crop by various means. Judicious use of water in micro-irrigation systems helps to improve the water use efficiency by saving water and brings down the overall irrigation costs by saving water, electricity and labour, e.g. In general, an average cost reduction of 31.9 per cent was achieved by farmers which were almost 50 per cent farmers from Gujarat. 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 cost, farmers have more choice to introduce new crops on their farms which is evident from the data that about 30 per cent of micro-irrigation adopting farmers have adopted new crops.

Electricity consumption in agriculture is about 20-25 per cent and the use of micro-irrigation techniques help in improving power use efficiency by 30-50 per cent 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 per cent. From 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 remains at optimal levels and in turn, increases the crop productivity, of fruit (42.3 per cent) as well as vegetable crops (52.8 per cent). This helps in increasing the income of the farmers. The economic viability analysis of micro-irrigation tilts in favour of farmers. Though, the farmer has to pay the installation cost at first, the benefits to the farmer is really promising and sustainable.

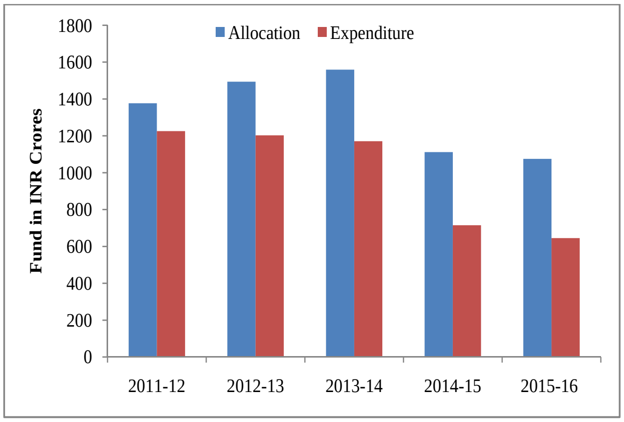
Current Status and Growth in India:

India now has close to 8 million hectare out of 140 million hectare of total area under cultivation through micro-irrigation, i.e. about 5.5 per cent average penetration at the all India level, much less than developed countries and even China. The real scenario is even worse as only some of the western, southern and northern Indian states particularly Rajasthan, Maharashtra and Andhra Pradesh have adopted this technology to some extent, but the performance of eastern and North-eastern states are the worst. Majority of the area covered under micro irrigation systems comes under sprinkler irrigation with 56.4 per cent, while 43.6 per cent comes under drip irrigation. However, area under drip irrigation has shown a stronger growth in recent years than sprinkler irrigation.

With half the cultivable land in the country still being rain-fed, there is mammoth potential for promoting micro-irrigation in India. To change this situation, there is need of strong political will, a dedicated team of extension personnel to create awareness among farmers about the importance of micro-irrigation and available Govt. Schemes along with a better and efficient administration delivering the inputs.

Future Potential:

Task-force on micro irrigation (2004) estimated a potential of 27 million hectares for drip irrigation and 42.5 million hectares for sprinkler irrigation with



a total potential of 69.5 million hectares out of arable land of 140 million hectares.

Table 2: Potential Area (million hectares) under Crops Suitable for Micro-Irrigation

Crop	Potential Area
Cereals	27.5
Pulses	7.5
Oil seeds	4.9
Cotton	8.8
Vegetables	6.0
Spices and condiments	2.4
Flowers, medicinal and aromatic plants	1.0
Sugarcane	4.3
Fruits	3.9
Coconut, plantation crops and oil palm	3.0
Total	69.5

(*Source: Task-force on micro-irrigations, 2004)*

Government Initiatives on Micro-irrigation :

The financial allocation by Government of India to micro-irrigation in different financial years and their utilization have been presented below:

The situation as targeted and achieved is alarming as about 40 per ent of the funds in the last two years have not been utilized. Previously, the Government targeted a growth rate of 0.5 million ha/per year coverage under micro-irrigation, which needs to be enhanced to achieve a sustainable growth in agriculture and achieve the potential. Realizing the grave problem, in 2017, Indian Government has allocated a corpus fund of Rs. 5000 crore on micro-irrigation to NABARD for achieving the goal of 'Per Drop More Crop', in addition to Rs. 50,000 crore to Pradhan Mantri Krishi Sinchayee Yojna for 2015-19 five year period.

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

i) **National Mission on Micro-irrigation: NMMI (2010-2014):** The NMMI is regarded as a strong and well visioned programme. Under this programme, the area under micro-irrigation almost doubled, growing from 3.09 million ha in 2005 to 6.14 million ha in 2012. Overall, many states achieved more than 90 per cent of set physical and financial targets.

ii) **National Mission for Sustainable Agriculture: NMSA (2014-15):** Under the head 'On Farm Water Management' component of NMSA, micro-irrigation issue is addressed. It emphasizes on enhancing water use efficiency by promoting efficient on-farm water management technologies and equipments. It also focuses on effective harvesting and management of rain water.

iii) **Pradhan Mantri Krishi Sinchayee Yojana: PMKSY (2015-2019):** It was launched in July 2015 for the period 2015-16 to 2019-20 with a financial outlay of Rs. 50,000 crores for 2015-19. The objective of the scheme is "to achieve convergence of investment in irrigation at the field level, expand cultivable area under assured irrigation." In short, there is a need to converge all ongoing efforts and to bridge gaps through location specific interventions.

Government is hoping to encash the many gaps through this scheme. It is realized that only about 20 per cent of rainfall is actually utilized by agriculture, only marginal increase in irrigation can bring an additional thousands of hectares under assured irrigation. It also emphasizes utilizing the potential groundwater reserve of 202 billion cubic meters. Micro-irrigation fits into the '*Per Drop More Crop'* component, which advocates improving water use efficiency by use of precision water application devices like drips, sprinklers, pivots, rain-guns etc. on the farms. It also aims to construct micro-irrigation structures like tube wells and dug wells, along with water lifting devices like diesel/electric/solar powered pump sets including water carriage pipes, underground piping system. Thus, this aims to create infrastructures on micro-irrigation within certain months, not years as in Watershed Development Scheme. This vision is welcomed from every sector involved in micro-irrigation, but the success rate is needed to be seen, as financial hurdles, administrative lags and awareness among farmers is still lacking. The vision is optimistic and can have far reaching consequences. A whole hearted approach from political, bureaucrats, extension workers and farmers is needed to achieve its objective.

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. Mitigating the effects of short-term drought is therefore a key step in achieving higher yields and water productivity in rainfed areas. Discussed hereunder are various means of enhancing use-efficiency and productivity of water in agricultural production system.

(i) **Avoid Over-irrigation:** Applying too much water to crops wastes soil and fertilizer as well as water. Frequent, light irrigations help keep water and mobile nutrients in the root zone where plants can use them. This practice is helpful in avoiding wastage of irrigation water as well as soil erosion.

(ii) **Select Crops and Cropping Systems Based on Available Water Supplies:** The crop selection for a particular agro ecosystem should be done on the basis of availability of water. As monsoon varies and water scarcity issue persists, aerobic rice varieties are being developed to require less water.

(iii) **Mixed Cropping System:** The water use efficiency in the mixed cropping fields of corn grasses were much higher than those in the fields where only corn or grass was grown. It is true for many mixed cropping systems.

(iv) **Irrigation Scheduling Based on Evapotranspiration (ET), Soil Water Content or Soil Water Tension:** Seasonal demand pattern for water varies from crop to crop. The optimal time to irrigate a particular field depends on the soil water-holding capacity, water extraction by the crops and rate of ET. Knowledge of water-holding capacity of the field soils helps in fixing the time for re irrigation. A sandy loam soil will not hold as much water as a silt loam, thus, it must be irrigated more frequently with less water per irrigation. Extra water is lost to runoff and goes deep into the ground. Moisture meter and tensiometer help in determining the moisture content in the soil. These instruments, when used with ET charts, provide a fairly accurate estimate of irrigation needs.

(v) **Use Full Irrigation at Critical Growth Stages and Deficit Irrigation at Rest of the Stages:** Deficit irrigation is irrigation that applies less water than the crop needs. Under deficit irrigation at non critical stages, the water productivity of the crops increases significantly with minor yield loss due to decrease in irrigation water input. Deficit irrigation particularly works well with deep-rooted crops such as wheat and corn, which minor test weight and yield loss. It is better to know each crop's tolerance of drought stress, and its irrigation should be done accordingly.

vi) **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. The retention of crop residues helps in reducing water loss from the soil to the air and cools the soil. Tillage exposes the soil to drying, conversely, reductions in tillage help conserve soil water. For strip tillage, cultivate only within the row zone and leave the inter-row zone undisturbed. This usually leaves at least 30 per cent of the previous crop residue on the surface after planting. Soil infiltration capacity of the inter-row zone is increased, allowing water to go where it's needed.

(vii) **Carefully Manage Surface Irrigation:** The irrigation efficiencies of surface irrigation systems are very low. They also bring a heavy flow of water in direct contact with soil, dislodging soil particles. Under surface irrigation, the top of the field often results in over-irrigation and the bottom is under-irrigated. Over-watering the top of the field stresses plants and causes nitrogen deficiency as nitrogen leaches below the root zone. Slightly drought stressing the bottom of the field often causes production losses similar to those caused by over-watering the top of the field. Mulch the bottom of the field with straw so the water that gets there soaks in.

To improve water infiltration in tight soils, polyacrylamide or straw mulch should be used 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. Compact the soft, non-traffic rows in furrow-irrigated fields, so their infiltration rate is similar to that of the wheel-traffic rows.

Switching over to micro irrigation methods like sprinkler irrigation or drip irrigation helps to manage water more efficiently and even often increase yields. Micro irrigation can save about 30-50 per cent of water than the amount used for furrow irrigation.

Present Challenges and Their Solution:

Micro-irrigation has penetrated only 5.5 per cent owing to various reasons which are discussed hereafter along with possible solutions.

i) **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. They need financing, but the procedure is not easy and the collateral is also very high. Though public and private sector financial institutions have devised special plans to support the farmers and manufacturers through different schemes, there are several flaws or lacking in their implementation. This needs to be sorted out and implemented effectively to accelerate the credit availability for purchase and installation of the micro-irrigation systems. Thus, easier financing norms will increase both the production and adoption rate of micro-irrigation systems.

ii) **Stable Scheme Guidelines and their Implementation:** It has been observed that schemes are only effective for 5 months of the year and are not available to the farmers during the peak demand months due to their uncertainty in guidelines for implementation. These are often very complex and in the recent years, have changed drastically year over year (NMMI to NMSA to now PMKSY). Thus, after missing the benefit of micro-irrigation in the peak cropping season, they could not realise the true benefits of a micro-irrigation system. This results due to the lack of smoother/ longer-term guidelines, which needs to be smoothened for faster approval and installation. The inefficiencies in the operating process for implementation results in this time lag along with their uncertainty of implementation. Therefore, ensuring availability of micro-irrigation system at the right time is needed to generate interests among the farmers. Delays in subsidy disbursement add to the plight. Thus, a dedicated team with clear and focused operational guidelines needs to be enforced to ensure its delivery at right time.

iii) **Use of Information Technology and Dedicated Team for Process Management:** The entire process, from application to installation and payment, should be backed by IT tools such as geo-tagging and referencing, which allow real-time monitoring of projects and helps to complete the process in time. A skilled and dedicated team focused on micro-irrigation further expedites the process.

iv) **Focusing Strategy for Water Intensive Crops:** Making drip irrigation mandatory for high water-consuming crops like sugarcane and rice etc. not only cuts water use, but also increases their productivity. Taking a crop-specific focus would yield quicker results with large areas brought under micro-irrigation in shorter periods of time.

v) Other Practical Approaches:

To promote the judicious use of the water, use of water should be charged a nominal amount by the government. The public water bodies should be managed by local bodies for their maintenance and usage. In addition, package of practice should be designed specific for regions and crops, which would describe both the equipments and guidelines for effective use of these systems for the specific region and crop in question.

Conclusion:

Though irrigated area occupies only 37% of the total cultivated land, it contributes 60% to the national food basket. It emphasizes the need of irrigation or on-farm need based water management practices to get optimum production. The 'More Crop Per Drop' principle needs to be followed for sustainable production and enhancing water productivity. This will also help to alleviate water scarcity and help in ensuring food security. 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.

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National Water Mission

The main objective of the National Water Mission (NWM) is "conservation of water, minimizing wastage and ensuring its more equitable distribution both across and within States through integrated water resources development and management". For achieving the objectives of the National Water Mission, long-term sustained efforts both in terms of time bound completion of identified activities and ensuring the implementation of identified policies and enactment of necessary legislation through persuasion at different levels with the State Governments have been envisaged. The five identified goals of the Mission are:

(a) Comprehensive water database in public domain and assessment of impact of climate change on water resource;
(b) Promotion of citizen and state action for water conservation, augmentation and preservation;
(c) Focused attention to vulnerable areas including over-exploited areas;
(d) Increasing water use efficiency by 20 per cent and;
(e) Promotion of basin level integrated water resources management.

Various strategies for achieving the goals have been identified which lead to integrated planning for sustainable development and efficient management with active participation of the stakeholders after identifying and evaluating the development scenario and management practices towards better acceptability on the basis of assessment of the impacts of climate change on water resources based on reliable data and information.

Jal Kranti Abhiyan:

Jal Kranti Abhiyan is being celebrated during the year 2015-16 to consolidate water conservation and management in the country through a holistic and integrated approach involving all stakeholders, making it a mass movement. It was launched on 5th June, 2015 across the country.

Objectives of Jal Kranti Abhiyan:

The objectives of Jal Kranti Abhiyan are :-

- Strengthening grass root involvement of all stakeholders including Panchayati Raj Institutions and local bodies in the water security and development schemes (e.g. Participatory Irrigation Management (PIM);
- Encouraging the adoption/utilization of traditional knowledge in water resources conservation and its management;
- To utilize sector level expertise from different levels in government, NGO's, citizens etc;
- Enhancing livelihood security through water security in rural areas.

Funding Arrangements Under Jal Kranti Abhiyan:

This is a convergence programme and no separate fund have been allotted for this Abhiyan. Expenditure on various works are being taken in each Jal Gram will be met from existing schemes of Central/State Governments, such as PMKSY, MGNREGA, RRR of water bodies, AIBP etc.

Implementation of the Programme:

This Ministry has issued two guidelines; one is general guidelines and second is step-by step implementation guidelines where the implementation of programme is detail have been enshrined. As per the guidelines, four tier of implementation committees from national level upto village level have been constituted.

In addition, the Nodal Officers of CWC/ CGWB in all the States/UTs have been appointed who are responsible for implementation of the programme in their allocated States/UTs. Simultaneously, a group of ten Joint Secretary level officers have been nominated to personally monitor their areas of States given to them for successful implementation of the programme.

The Ministry of Water Resources, River Development & Ganga Rejuvenation is also conducting video conferencing from time to time with the State Govt. officials and the Nodal Officers therein and keeping the watch regularly for implementation of the programme.

Monitoring Mechanism:

At the National level, there is a national level committee under the chairmanship of Special Secretary (WR, RD & GR) who is looking after the overall implementation of Jal Kranti Abhiyan at the national level. Similarly, at the State level, there is a State Level Monitoring Committees under the chairmanship of Principal Committee of the respective States who are responsible for the implementation of the Abhiyan at the State level.

Activities under Jal Kranti Abhiyan:

The activities/components being undertaken the Abhiyan are :-

- **Jal Gram Yojana:** Jal Gram Yojana is one of the most important activity of the Jal Kranti Abhiyan under which 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 being prepared to ensure optimum and sustainable utilization of water. A committee at village/block level is being formed for implementation and monitoring of works under Jal Gram Yojana for every Jal Gram. The role of the village level committee are :-

(i) Providing inputs for formulation of water security plan

(ii) Implementation of works

(iii) Monitoring of works

(iv) Advocacy of water conservation in village

(v) Meeting once in a fortnight.

- **Development of Model Command Area:** Under Jal Kranti Abhiyan, a model command area of about 1000 hectare in a State shall be identified. States adopted for model Command area should represent different parts of the country for example Uttar Pradesh, Haryana (North), Karnataka, Telangana, Tamil Nadu (South), Rajasthan, Gujarat (West), Odisha (East), Meghalaya (North East) etc. Model command area shall be selected from an existing / ongoing irrigation project in the state where funds for development are available from various schemes. Selection of Model Command Area shall be done by Ministry of Water Resources, River Development and Ganga Rejuvenation in consultation with States Governments.

- **Mass Awareness Programme:** Mass awareness campaigns designed to address problems and suggest solutions to meet the requirements of each segment of the society under the continuing scheme of "Information, Education and Communication". The focus will be on:-

i. Use of Social Media like Facebook, Twitter, etc. to engage the citizens;

ii. Awareness programme for the general public on radio and television;

iii. Use of print media (e.g. booklets, posters and pamphlets) to spread awareness on Jal Kranti Abhiyan.

iv. Awareness programme for children and adult through essay, painting & other competitions;

v. International Water User Exchange Programme;

vi. Specific activities targeting the policy planners and opinion makers; and

vii. Organization of conferences, workshops on important water development and management issues.

viii. Pollution abatement

Under the mass aware programme, training/workshops across the country are being organized to make about the water conservation and water management, apart from that essay competition and other national level conferences are also being conducted. Radio jingle programmes are also underway.

- **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/ strengthen their State Water Resources Council and State Water Regulatory Authority.

Water Storage Level of 91 major Reservoirs of the Country goes up by Five per cent

The water storage available in 91 major reservoirs of the country for the week ending on September 28, 2017 was 103.429 BCM which is 66 per cent of total storage capacity of these reservoirs. The level of water storage in the week ending on September 28, 2017 was 89 per cent of the storage of corresponding period of last year and 87 per cent of storage of average of last ten years.

The total storage capacity of these 91 reservoirs is 157.799 BCM which is about 62 per cent of the total storage capacity of 253.388 BCM which is estimated to have been created in the country. Out of these 91, 37 Reservoirs have hydropower benefit with installed capacity of more than 60 MW.

HARVESTING RAINWATER FOR AGRICULTURAL NEEDS

Dr. Sharad K Jain, Dr. J.V. Tyagi

The concept of watershed development is important in efficient management of rain water. The RWH with storage facility should form an integral part in WDPs which has a crucial role in providing the life saving irrigation to the standing crops when they are exposed to mid-term drought and also for pre-sowing irrigation in post-rainy crops in rainfed areas. Since substantial funding is required for the creation of RWHS, it calls for public support.

Rainfed agriculture in India is practiced in about 57 per cent of an estimated 140.3 m ha net cultivated area and India ranks first among the rainfed agricultural countries of the world in terms of both extent and value of produce. It contributes 40 per cent of food grains and supports 40 per cent of the population, 80 per cent of horticulture and 60 per cent of livestock[1]. The importance of rainfed agriculture is obvious from the fact that 55 per cent of rice, 91 per cent coarse grains, 90 per cent pulses, 85 per cent oilseeds and 65 per cent cotton are grown in rainfed areas[2].

Characteristics and Issues with Indian Rainfed Agriculture:

Rainfed areas in India are highly diverse. It is practiced 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, a significant fall in food production is often noticed.

The rainfed agriculture in India is mainly 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[3]. 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 includes 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. The increased use of fertilizers alone, often in an unbalanced manner, has degraded soil quality and exacerbated multiple nutrient deficiencies. 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. Also, the traditional markets in rural areas are unregulated and unprofitable, and the small and marginal farmers operate independently without pooling the produce for efficient marketing. Thus, 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[4]. 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[5]. 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 the potential strategy to achieve the desired level of yields in these areas. Prolonged dry spells during flowering, pollination and seed formation stages of a crop are highly detrimental to yield. The use of harvested rainwater for one or two life-saving irrigations of *Kharif* crops during mid-season drought can increase the average yield of rainfed crops substantially.

Methods of RWH:

- **In-Situ Water Harvesting:**

It refers to collection of rainwater where it falls for use on the same surface (often called in-situ water conservation). The methods mainly include contour bunding, field bunding, ridge and furrowing, contour trenching and contour cultivation. The selection of a particular method depends on the topography, nature and depth of soil, rainfall intensity and amount, infiltration and water holding capacity of soils, and land use etc. These methods increase the time of concentration and provide an opportunity for the infiltration of water. The 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/or runoff for its beneficial use e.g. for raising agricultural and horticultural crops or for domestic and livestock consumption. These methods are also considered very useful for groundwater recharge both when rainfall is deficient and when there are flash floods. The various methods of RWH, categorized as traditional and contemporary, are briefly presented below.

- **Traditional methods:**

❖ *Village ponds and tanks* are the most commonly used methods to collect and store rainwater. Ponds are excavated in different shapes and sizes depending on the nature of the terrain, availability of land and water requirements of the village community. Pond water is generally available for 2 months to a year after the rains, depending on the catchment characteristics and the amount and intensity of rainfall.

❖ *Tankas/kunds/kundis* are underground structures of various shapes and sizes to collect rain water for drinking purpose in the desert and arid areas of Rajasthan. These are built both for individual households as well as for village communities using locally available materials. Tanka is constructed by digging a circular hole of 3-4.25 m diameter and plastering the base and sides with 6 mm thick lime mortar or 3 mm cement mortar with stone slab coverings.

❖ *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. In this system, runoff from upland and rocky surfaces is collected in the adjoining valley by enclosing a segment with an earthen bund. The Khadin system is based on the principle of harvesting rainwater on farmland and subsequent use of this water-saturated land for crop production.

Khadin

- *Vav/baoli/bavadi/jhalara* are traditional wells in Rajasthan and northern India. Often rectangular in design, these structures have steps on three or four sides. These ancient water harvesting systems collect subterranean seepage of a talab/lake located upstream. They were mainly set up by the nobility in cities to provide water supply to the community.

Baoli

Vav

- *Hill slope collection system* is common in many hilly areas with good rainfall e.g. in Uttarakhand, Himachal Pradesh, Meghalaya, and Arunachal Pradesh. It consists of lined channels built across hill slopes to intercept rainwater. These channels convey water to agricultural fields or to fill small ponds.

- **Contemporary methods:**

- *Check dams and nalla bunding* consist of an embankment across small streams and long gullies with a waste weir at suitable place. The impounded water is used by cattle or for life saving irrigation. The impounding also facilitates percolation of water into deeper soil and makes it possible to bring under cultivation the land under the bed of the nallas.

- *Farm ponds* are useful in storing water for supplemental/life saving irrigation. A good pond site should have a narrow gorge for earthen bund construction so that a small amount of earthwork provides large storage. The drainage area above the pond should be large enough to fill the pond in 2 or 3 spells of good rainfall. The pond location should be near where the water is to be used, e.g. for irrigation, it should be above the irrigated fields. The land surface should not have excessive seepage losses.

- *Percolation tanks* impound rainwater and have a waste weir to dispose of the surplus flow in excess of the storage capacity of the tanks. Percolation tanks are generally constructed on the small streams or rivulets with adequate catchment for impounding surface runoff. These tanks are used entirely for recharging the aquifer through percolation.

- *Sub-surface barriers,* constructed below river bed on impervious subsurface strata, are the most suitable artificial structure for promoting ground water recharge in arid and semi-arid regions. Such barriers are quite suitable structures as they are safe from flood havoc, evaporation losses and do not need elaborate overflow arrangement and periodic de-sitting.

- **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 (WDP) taken up under different schemes of the Government of India (GOI) and the state governments. The watershed approach provides for technological options for in-situ conservation of rainwater, runoff water harvesting for groundwater recharge and supplemental irrigation, appropriate nutrient and soil management practices, crop production technology, and appropriate farming systems with income generating micro-enterprises for improving livelihoods in dry and rainfed areas. The scientists and engineers have developed a variety of technologies which offer solutions in different conditions. The solutions include interventions ranging from simple check dams to large percolation tanks, from vegetative barriers to contour bunds, and changes in agricultural practices. A hierarchy of institutional arrangements of the government and other agencies undertake the planning and implementation of WDPs. In India, three ministries at the Centre namely, the Ministry of Agriculture (MoA), Ministry of Rural Development (MoRD) and Ministry of Environment, Forest and Climate Change (MoEFCC) along with some respective departments in the states are involved in policy formulation and implementation of WDPs.

The WDP was initiated by GoI in 1949 and a special centre was established at Jodhpur in 1952 (designated as CAZRI in 1959) to tackle the problem of drought and desertification. Dry Farming Projects which emphasized water conservation measures in drought affected areas were launched during 2nd and 3rd Five year plans. The focus continued on dryland farming and the All India Coordinated Research Project for Dryland Agriculture was started during 4th Plan. Based at CRIDA, Hyderabad, the project consisted of 24 pilot projects that served as training-cum-demonstration centres for technology relating to RWH, soil management, improved agronomic practices and drought resistant crops. The Drought Prone Areas Programme (DPAP) was launched in 1970-71 with the designs to reduce the severity of drought in the affected areas. Desert Development Programme (DDP), initiated in 1977-78, emphasized on afforestation and livestock development. In 1980, a new scheme called Integrated Watershed Management in the Catchments of Flood Prone Rivers (FPR) was started by the MoA. The concept of integrated watershed development was formalized in 1990 and the National Watershed Development Project for Rainfed Areas (NWDPRA) was launched in 99 watersheds, which covered 2554 micro-watersheds in 1994[6].

A technical committee, constituted by GoI in 1993 under the chairmanship of C.H. Hanumantha Rao, reviewed the effectiveness of these programmes and reported that the programmes were implemented in a fragmented manner by different departments through rigid guidelines without any well-designed plans on watershed basis. As a result, the achievements were dismal in many areas and the ecological degradation continued unabated in many of these areas with reduction in forest cover, water table and a shortage of drinking water[7&8]. The Committee, therefore, suggested for participatory modes of implementation through involvement of beneficiaries and NGOs. A new set of guidelines was then implemented in all the WDPs of the MoRD w.e.f. April 1, 1995. From April 1, 2003, all new development programmes were implemented through Panchayati Raj Institutions (PRIs) with the guidelines for Hariyali programme. In November 2006, an apex body named as National Rainfed Area Authority (NRAA) was established to give focussed attention to rainfed areas of the country. This advisory body formulated common guidelines for the WDPs in consultation with all the States for its implementation. Evolving the design of the wage employment programmes, the GoI formulated MGNREG Act in 2005 to fight poverty more effectively. A majority of the permissible works had to be carried out under MGNREG scheme related to water harvesting, groundwater recharge, drought-proofing and flood protection.

For evaluating the effectiveness of WDPs, countrywide studies were taken up by the MoRD through various agencies in coordination with National Institute of Rural Development (NIRD), State Institute of Rural Development (SIRD) and ATIs etc. The evaluation reports of these agencies encompassed 1044 micro-watersheds of different schemes in 105 districts of 12 states across the country. Later, the Centre for Rural Studies, Lal Bahadur Shastri National Academy of Administration (CRS, LBSNAA) carried out secondary review and analysis of these reports and concluded that the quality of rainwater harvesting structures (RWHS) in majority of micro-watersheds in Tamil Nadu and Gujarat was either good or very good. In states like UP, MP, and Maharashtra, the quality was reported to be either average or good, while in J&K, the quality was reported below the mark[9]. The study noticed positive changes in groundwater levels, surface water availability, irrigation facility, water regeneration capacity, land use pattern, cropping pattern, livestock production, employment generation, income generation and debt reduction in all the WDPs with certain variations. However, some issues related to RWHS were also reported that included poor maintenance during post implementation phase, no people participation during construction in some states like J&K, lack of adequate institutional mechanism and no equity and benefit sharing mechanisms among user groups, PIAs, etc. Besides above, many researchers have also reported positive impacts of RWHS in terms of increased soil moisture levels, increased groundwater levels, increased water availability for water saving irrigation during critical dry spells and increased levels of yields in rainfed agriculture.

Way Forward:

Upgrading rainfed agriculture requires same level of concerted water governance and management priorities as given to the irrigated agriculture during the past six decades. Concerted efforts are also required for building up institutional capacities, policy frameworks, knowledge generation, and public finance for RWH in rainfed agriculture. The concept of watershed development is important in efficient management of rain water. The RWH with storage facility should form an integral part in WDPs which has a crucial role in providing the life saving irrigation to the standing crops when they are exposed to mid-term drought and also for pre-sowing irrigation in post-rainy crops in rainfed areas. Since substantial funding is required for the creation of RWHS, it calls for public support. Also, most RWHS are reported to have a favourable mean cost-benefit ratio. Apart from enhancing the availability of water by RWHS, the water-use efficiency needs to be increased through adoption of modern irrigation methods like drip and sprinklers. Awareness on RWH and water conservation should be created among the masses through education, mass media, regulation, incentives and disincentives.

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RAINWATER HARVESTING AND RAINFED AGRICULTURE IN INDIA

J. S. Samra

Almost entire area under forests, grazing/grasslands, 80 per cent of horticulture, 60 per cent of net sown area is rainfed. Nearly 84-87 per cent of pulses and coarse cereals, 77 per cent of oilseeds, 60 per cent cotton and 50 per cent of fine cereals are contributed by the rainfed agro-ecologies. Special attributes crops of guar gums, spices, organic dies and medicinal plants are other unique features of semi-arid and arid regions. Rainfed agriculture ,therefore, is a major agenda of Government policies, programmes, governance and investment portfolios in India.

In India, rainfed and under invested agriculture supports 40 per cent of population, contributes 44 per cent of food grains, 60 per cent of livestock and is a major driver of rural development which is far behind the urban sector. Productivity of natural resources including rainfall is low as well as risky due to poor management of water and other inputs. Rainfall/precipitation is the ultimate source of *in situ* soil and water conservation, aquifer recharge, water harvesting for limited irrigation, river flows and reservoirs of dams for assured irrigation. Productivity of irrigated agriculture is 1.5 to 2 times more than rainfed farming. After having exhausted all irrigation potential, 50 per cent of agriculture will continue to be dependent on rain. Almost entire area under forests, grazing/grasslands, 80 per cent of horticulture, 60 per cent of net sown area is rainfed. Nearly 84-87 per cent of pulses and coarse cereals, 77 per cent of oilseeds, 60 per cent cotton and 50 per cent of fine cereals are contributed by the rainfed agro-ecologies. Special attributes crops of guar gums, spices, organic dies and medicinal plants are other unique features of semi-arid and arid regions. Rainfed agriculture, therefore, is a major agenda of Government policies, programmes, governance and investment portfolios in India.

On an average, India receives about 89 cm (4,000 billion cubic meters) of rainfall and country is blessed by the nature. However, it is not uniformly distributed, floods in some parts and simultaneously droughts in other parts are quite common. About 75 per cent of the total rainfall is received in four months only (June to September). Of late, climate change has further increased frequency and intensity of extreme weather events of floods, droughts, heat/cold waves, hail storms, cyclones, etc. Ancient literature of Rig Veda, Arthashastra and other describe various practices of rainwater harvesting (Sharda et al 2017). Management of risks, uncertainties and climate smart agriculture by rainwater conservation and harvesting is called upon for resilience of livelihood, food and nutritional securities.

***In Situ* Rainwater Conservation/Harvesting:** Highest priority is to preserve rainwater wherever it falls to recharge soil profile, ground water and surface storage. It also improves surface and sub-surface flows perennially. Surface runoff harvesting and storage structures, roof top rainfall collection into cistern or ground water recharging, dugout ponds, tanks, *tankas, khadins, ahars/Havelis*, check dams, stop dams, gully plugs are several water harvesting structures known by different regional names. *In situ* rainwater conservation is achieved by land shaping, contour or field bunding, cultivation, sowing, various other mechanical or vegetative barriers, terracing and trenching along the contours. It also cuts down erosion of soil, seeds, vegetative propagules and siltation of water bodies. Over exploitation of ground water and its maladies can be remedied by ground water recharging only.

Fig.1. Rainwater harvesting, efficient conveyance, in situ conservation and recharging of wells in Bundelkhand region.

Safe landing and Transport of Surface Flows:

Safe landing of runoff into water harvesting structures and natural drainage system is ensured by constructing both mechanical and vegetative structures. Water velocity is also reduced by treating gullies, *nallahs*, streams, drains, with loose boulders, wire crates, spurs, etc. This provides maximum opportunities (residence time) of recharging and minimize the cutting of banks and stream beds. In addition to recharging aquifers, they also provide limited irrigation at critical stages and minimize risks of erratic rainfall.

Sub-surface Flow Harvesting:

Water springs in the hills and mountain ecosystem is a classical example of sub-surface flows harvesting. Drying of the springs can be prevented and regular flows ensures post rainy season by *in situ* recharging of rains, improving and preserving vegetation in the catchment areas. There are other structures of sub-surface dams/barriers, *bandhars,* diaphragm dams, collector wells, infiltration galleries as sub-surface dams to harness sub-surface flows.

How It Helps Agriculture:

In situ rainfall conservation regenerates and enhances biomass production of grasses, shrubs, trees and other forages, enhanced productivity of grains and crops residues as fodder. It reduces the socially undesirable seasonal migration of herders by 35-100 per cent, number of goats, stall feeding increased bovine population, milk productivity and income of the farmers. Irrigation with surface and underground stored rainwater leads to economically better crop diversification, higher inputs due to reduced risks and improved profitability. Cropping intensity is enhanced by 63.5 per cent and generates additional employment @ 182 person days/ha / annum. Crops yield increases in the range of 5 to 91 per cent. A benefit/cost ratio of more than 2 and 22 per cent internal rate of return made investment economically viable (Joshi *et al.,* 2008). An average reduction of 13 per cent in the rainwater runoff and 0.82 tonnes/ha/year soil loss improves environmental qualities in several dimensions. Ground water can be raised in the range of 2 to 5 meters and improved irrigation potentials for post rainy season period.

Govt. Policies, Programmes and Governance:

Rainfall being the ultimate source of water has always attracted attentions of saints, philosophers, kings, rulers, democracies and politicians since beginning of the civilization. Water has been treated as a sacred or divine gift in the ancient literature. It was considered an open access, shared and common property resource and did not attract corporates and investors. Conservation and harvesting of rainwater for realizing all kinds of environmental services, food, nutritional and income securities of poor was always a priority of public investments. Demographic growth led to various kinds of water conflicts and participation of all kinds of stakeholders was ensured by very unique, innovative and out of box policies and programmes. Catchment treatment from ridge to valley within the boundaries of a watershed is the fundamental principle. Therefore, the management of wasteland, forest area, private and community land for growing grasses, trees, crops, livestock rearing and other livelihood is the theme of the current policies (Fig. 2). NRAA devised watershed development guidelines in 2008 based on principles of equity, gender sensitivity, decentralization, facilitating agencies/institutions, community participation, capacity building and technical inputs, organizational restructuring etc. These guidelines were further revised in 2011 and subsequently also to ensure transparency, ownership and sustainability by the local community through their contributions, equitable sharing and higher efficiency. Convergence and coordination with MGNREGA, rural livelihood and other schemes supplemented and complemented inputs. Rainwater harvesting and recycling has always been an evolving process and shall continue to do so.

Suggestions:

Global warming has increased frequency and intensity of droughts, floods, cold/heat waves, other

Fig. 2. A typical watershed

Fig 3: Subsurface flow harvested in V. Kalimati, Dehradun, Uttarakhand.

extreme events and risks. Rainwater harvesting can ensure climate smart agriculture and resilience in agriculture. Simultaneous occurring of floods in some parts and droughts in other parts calls upon inter-linking of rivers. Minimizing water storage and conveyance losses, most efficient micro-irrigation system and protected cultivation can ensure optimum use of limited water resources.

Insurance of crops, livestock, agro-forestry and products portfolio, establishment of banks of fodder, water, seeds can minimize the risks and farmers distress. Special credit and debt services and other safety nets keeping in view, the vulnerability to periodic crop failures is called upon. Market volatility of special attribute crops of arid and semi-arid region like Guar Gum etc. and trading in value added products can ensure doubling of the farmers' income. Robust and climate smart farming systems, integration of on farm and non-farm activities and convergence with MGNAREGA can minimize seasonal migration. Co-generation of renewable and cheaper non- grid wind and solar energy have tremendous potential for promoting micro-irrigation, protected crop cultivation and other power needs of arid and semi-arid regions especially all along the west coast. Unique and innovative agri-voltaic system for doubling farmers income are in progress at ICAR-CAZRI, Jodhpur.

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NMCG to use latest Geo-Spatial Technologies for Namami Gange Programme

Ministry of Water Resources, River Development and Ganga Rejuvenation will now make optimal use of latest geo-spatial technologies to rejuvenate river Ganga. For this, National Mission for Clean Ganga (NMCG), National Remote Sensing Centre (NRSC) and Survey of India will work in an integrated manner to take all steps to clean Ganga and execute it in a time-bound manner.

National Remote Sensing Centre (NRSC), which is a part of Indian Space Research Organization (ISRO) has been supporting NMCG to use geospatial technology for water quality monitoring, hydrological monitoring and evaluation, geomorphological monitoring and evaluation, bio-resources monitoring and evaluation, comprehensive geospatial database, develop mobile application for enabling community participation and to co-ordinate necessary linkages with other agencies. The support is aimed at achieving the objective of monitoring of pollution in river Ganga. NMCG also strives to achieve GIS mapping of the entire Ganga river basin for effective execution and decision-making.

Some of the tasks enlisted by NRSC as part of support to NMCG are generation of comprehensive GIS database, water quality assessment using satellite data of main Ganga from Kannauj to Varanasi, real time water quality data visualization, high quality multispectral satellite image, aerial topographical survey, urban sprawl change mapping, non-point source pollution assessment etc. A holistic approach is being adopted by NMCG to keep river Ganga clean by identifying five km. stretches from the edge of the bank/ flood plain to the nearest main road for a comprehensive planning approach.

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

Dr. R.K. Sivanappan

To become a developed nation, India should be top in Agriculture and also top in agricultural production. 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 as mentioned above 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. it is thus, necessary to take up the interlinking of rivers in India, particularly interlinking of peninsular rivers without wasting of time and to implement the Supreme Court orders / direction as early as possible.

India is one of the few countries in the world endowed with reasonably good land and water resources. The average annual rainfall of the world is 840mm, whereas in India, it is 1150mm. 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 reason is that the rainfall is erratic and getting only 3 to 4 months in a year (within 100 hours). Further, it is not uniform throughout the country. The per capita availability of rain (water) in different basins of the country is having vast variations. It varies from 18,417 m^3 in Bhramaputra basin, 3640 m^3 in west flowing rivers, 2546 m^3 in Mahanadi basin, about 660 m^3 in Cauvery basin and as low as 383 m^3 in some east flowing rivers in Tamil Nadu.

Flood and Drought Management:

a. **Flood Management:** In India, the flood damages are on the increase due to people's encroachments of the water flow areas of the rivers and also due to silting of the rivers, since they are not maintained by the people or Government properly. Further, there is no water diversion to store the flood water flowing in the streams. The solution is to assess the problems of floods by the agencies concerned. For comprehensive flood and drainage management, it is necessary to assess the extent of water logged area during and after the monsoon. The structural measures of flood management include constructing embankments including tanks to store excess (flood) water and channel improvements etc. The flood affected areas are in North and North East parts of the country.

b. **Drought Management:** It is estimated that about 1/3 of the area in India is drought prone area and large areas are in the south and western parts of the country. Drought is a natural disaster and represents a situation of water shortage and this is due to rainfall failure in the basin or inadequate rainfall causing moisture stress etc. Drought is a situation occurring in an area where

the rainfall is less than 75 per cent of normal rainfall in the basin. The drought area should be made less vulnerable through soil moisture conservation measures, water harvesting practices, minimizing evaporation losses etc.

Water Availability:

The average availability of water in India is about 2000 m^3 per person per year. It will be further reduced in the coming years as the population is increasing at the rate of about 2 per cent per annum though 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 m3, it is considered as a water scarcity state. The problem of water scarcity / drought is a man made problem in the country as we are not harvesting, conserving and managing the available water (Rain water) scientifically and we are not considering India as a country for all the citizens living in the country. 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.

As the demand of water is increasing day by day for drinking in Household and industrial use, the availability/allotment of water for irrigation will have to be reduced from the present 85 to 70 per cent or so in another 15-20 years. At the same time, the food production has to be increased for the growing population i.e from 240 MT in 2010 to 450 – 500 MT in 2050 i.e doubling the yield with less water available for agriculture as stated above. Further, it is possible in view of the fact that out of 195 MHM or 70,200 TMC of surface (River) flow in India, at present, only about 69 MHM or 24,840 TMC i.e. only 35 per cent is useable quantity (as estimated 40-50 years back) and the remaining water of 65 per cent is allowed to join into the seas every year and that must be correctly assessed so that more water for agriculture will be available to produce the required food (450-500 M.T.) in 2050.

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. Ie about 27 MHa +42.50 MHa (Drip + Sprinkler) = 69.50 MHa respectively.
f. Interlinking of rivers in the country.

Salient points to be considered to solve the problems:

- The surface water resource of the country is about 195 MHM and the replenishable groundwater is 43 MHM as reported by the National Commission for Integrated Water Resources and developed plan, Government of India in 1999, totaling about 238 MHM. The total utilizable water is noted as 69 MHM out of 195 MHM of surface water (i.e. 35 per cent). This statement is there for the last 40 / 50 years.
- This figure i.e. utilizable water mentioned seems to be not correct and it should be revised/ updated and accurately assessed.
- The water storage capacity created per person in different countries in the world including India are as follows.

Country	Storage created / per person in M^3
USA	5961
Australia	4717
Brazil	3388
China	2486
India	200

- There are about 45,000 large dams in the world of which 46 per cent is in China, 14 per cent is in USA, only 9 per cent is in India, Japan 5 per cent and Spain 3 per cent etc (Report of the committee on large dams). Our environmentalists are against the construction of dams (Reservoirs) to store the flood water going as waste giving some reasons.
- The storage capacity created in USA is about 65 MHM compared to India's 18 MHM and it may go to about 36 MHM after all works under

constructions and contemplated. The fact is that both countries have the same quantity of water from the rain and USA's population is only 30 crore compared to India's population of 121 crore.

- China's ambitions of $80 billion projects to divert waters of southern river (Yantze) to the arid north (Yellow river) is nearing completion. There is another plan in hand to divert our Brahmaputra's water to Northern China (the Hindu dated 7.2.2012) which will affect India's water resources.
- The storage capacity of Aswan Dam in Egypt can store 2 years of rain from the catchment areas. The Boulder dam in USA can store all the run off water and no water is over flowing from the Dam after its construction (Sandra Postel, Pillar of Sand, WW Norton and Co., New York, 1999).
- There are many reports of the National Water Development Agency, New Delhi prepared from 1982 to 2012 i.e. 30 years work with more than 200 engineers on feasibility reports and cost estimates for some diversions especially for peninsular rivers and west flowing rivers to East in Karnataka and in Kerala state etc.
- Mr. Suresh P. Prabhu, former Chairman of the task force on interlinking of rivers Government of India, New Delhi submitted a detailed report to the then Prime Minister of India in 2004 with details about interlinking of rivers in peninsular India.
- The historic pronouncement on 31st October 2002, the Supreme Court asked centre to set up a high level task force to work out the modalities for interlinking of rivers in India within 10 years.
- In another judgment of the Supreme Court (27.2.2012) directed the centre to implement interlinking of rivers in a time bound manner and constitute a panel of ministers, experts and activists to sort out and to execute the project as it has been already delayed resulting the increase in cost.

Conclusion:

As discussed, the water availability in the country is plenty, but it is unevenly distributed and hence, the water scarcity problem exists in some parts of the country especially in the western and southern states. The unused water which is flowing be into the sea in the southern states works out to (2000 TMC of water is flowing in Arabian sea in Karnataka state, 500 TMC, the excess over the demand in Kerala state and 810 TMC from Mahanadhi, Godavari and Krishna rivers, as surplus water estimated by NWDA totaling about 3300 TMC can be diverted to the needed states like Tamil Nadu, Karnataka and Andhra, which can easily irrigate about 10 – 15 mHa. The excess water in the Northern rivers namely Ganga, Brahmaputra and other northern rivers after detailed study can be diverted to the needed states.

Our dream is that India should become a developed country in 2020 / 2025. To become a developed nation, India should be top in Agriculture and also top in agricultural production. 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 as mentioned above 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. It is thus, necessary to take up the interlinking of rivers in India, particularly interlinking of peninsular rivers without wasting time and implement the Supreme Court orders / direction as early as possible.

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SUSTAINABLE AGRICULTURE: ALIGNING CROPPING PATTERN WITH THE AVAILABILITY OF WATER

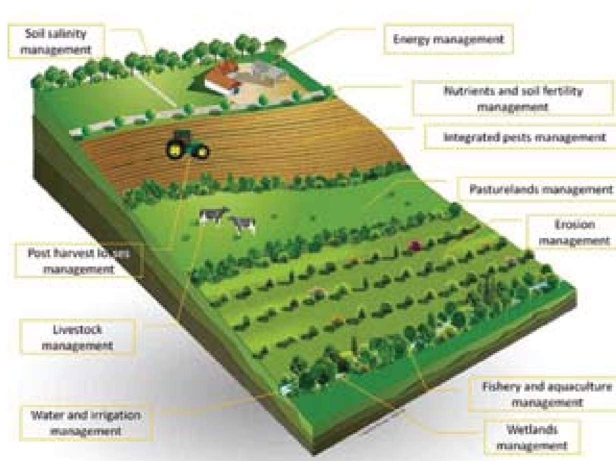
Dr. Y S Shivay , Dr. Teekam Singh

The agricultural technology needs to move from production oriented towards profit oriented sustainable farming. The conditions for development of sustainable agriculture are becoming more and more favourable. 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. This will create millions of micro economies with sustainable utilisation of water resources in the water abundant regions.

In In India about 75% people are living in rural areas and are still dependent on agriculture, about 43% of India's geographical area is used for agriculture activities. The estimated food grain production in India is approximately 275 million tonnes during 2016-17. But still Indian agricultural production systems are facing the challenges of increasing food production to meet ever increasing population without damaging the future resource base i.e. ecosystem in the most of the developing countries. In India, there are many reasons to focus on agriculture and allied sector as it will continue to play a significant role in providing employment and sustainable livelihoods for the growing population. However, 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. The present conventional farming can however be improved by adopting appropriate technologies of crop production, post-harvest processing and by improving quality so that agriculture becomes not only sustainable in long-term but a profitable business also by linking production with consumerism. Rice–wheat cropping system is the backbone of India's food security as both crops contribute more than 80% to the total food basket of India and also utilizes large portion of irrigation water in this process. Thus, sustainable agricultural production system is the key to improve yield potential and eco-efficiency simultaneously for the rice–wheat rotation system in India to keep self sufficiency of food grain in long-run.

Sustainable agriculture is the way of farming according to the location-specific ecosystem and study of relationships between organisms and their environment. Simply stated, sustainable agriculture is a form of agriculture aimed at meeting the needs of the present generation without endangering the resource base of the future generations. Thus, a holistic and systems approach is essential for achieving sustainability. Such systems must be resource-conserving, socially supportive, commercially competitive and environmentally sound. Such systems aim to produce qualitative and nutritious food without harming human health and ecosystem. Thus, such systems generally avoid the use of synthetically compounded fertilizers, pesticides, growth regulators and livestock feed additives, instead relying upon crop rotations, crop residues, animal manures, legumes, green manures, off-farm organic wastes, appropriate mechanical cultivation, and mineral bearing rocks to maintain soil fertility and productivity. There are following ways to sustain agricultural productivity:

- Soil management through conservation agriculture, organic farming, integrated nutrient



management system and on-farm residue management

- Efficient water resource management techniques like right method of irrigation, micro irrigation, life saving irrigation, use of mulches, anti-transparent etc.
- Crop management includes right time of sowing, cultivation of suitable crops and varieties in rotation, intercropping, mixed-cropping, integrated pests management etc.

The sustainability in agriculture i.e., for crops/ cropping systems is primarily depends upon the availability of water in its optimum quantity and acceptable quality. Rainwater is the primary source to meet the demand of water in Indian agriculture. From rainfall, India annually receives a rainfall of 1,085 mm. This rainfall is equivalent to roughly about 400 M hectare meter water. Nearly three fourths of the total rainfall received in India is through South-West monsoon activity (Table 1). Not even 3% of the total precipitation is contributed by North-Eastern monsoon. The remaining amount of rainfall comes via pre or post monsoon activity.

Table 1: Distribution of Annual Rainfall according to Seasons in India

Type of rainfall	Duration	Amount (mm)	% of annual rainfall
Pre-monsoon	March-May	112.8	10.4
South-West monsoon	June-September	799.6	73.7
Post-monsoon	October-December	144.3	13.3
Winter or north-east monsoon	January-February	028.2	02.6
Total		1085*	100.0

**Total annual rainfall = 1,085 mm (long-term average, 1950 to 1994)*

Prevailing conditions and location-specific path of progressing monsoon play a significant part in deciding the regional disparities observed in rainfall distribution and availability. Employing average annual rainfall as the criteria, 30% of the area in the country receives less than 750 mm, 42% of the area gets between 750 and 1,150 mm, and 20% of the India's earth has access to rainfall between 1,150 and 2,000 mm. It is only 8% of the land area, which secures more than 2,000 mm rainwater annually. Thus 70% of the land area receives rainfall greater than 750 mm. The water resources potential of the country which occurs as natural run-off from rainfall and snow melt into rivers and streams is about 186.9 M ha m as per the estimates of Central Water Commission, considering both surface and ground water as one system. Due to various constraints of topography, uneven distribution of resource over space and time, it has been estimated that only about 112.3 M ha m of total potential of 186.9 M ha m can be put to beneficial use, 69 M ha m being due to surface water resources and 43.3 M ha m due to ground water resources. This 112.3 M ha m would be used for irrigation, domestic and industrial purposes. Thus, practically the water available for irrigation to agricultural crops will be inadequate. So enhancing the efficiency of water use is an important option; and if India has to remain self-reliant in her food needs, there is no choice except to save every drop of water and use it most prudently for sustainability in agriculture.

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). Many parameters like crop growth stage and its sensitivity to water stress, climatic conditions and water availability in the soil determine when to irrigate or the so-called irrigation frequency. However, this frequency depends upon the irrigation method and therefore, 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 is the key to improving performance and sustainability of the irrigation systems. In most cases, the skill of the farmer determines the effectiveness of the irrigation scheduling at field level. Irrigation scheduling techniques and tools varies greatly and has different characteristics relative to their applicability and effectiveness. Timing and depth criteria for irrigation scheduling can be established by using several approaches based on soil water measurements, soil water balance estimates, critical crop growth stages and plant stress indicators, in combination with simple rules or very sophisticated models.

As water is the limiting factor for crop production, the sustainable cropping systems which ensured efficient in using available soil moisture and supports the maximum soil moisture conservation are to be adopted under moisture deficit situations. The conventional crops and cropping patterns prevailing in most of the dryland areas do not take care these aspects and 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 systems and their management should aim at most efficient use of water over wide range of rainfall situations. Any cropping system comprising crops with varied maturity period, crop canopy, high yielding potential is today's need for an average farmer. Single crop system consisting of red gram, cluster beans, French beans, castor, setaria, groundnut, pearlmillet, ragi, mustard, sunflower are best suited. However, several cropping systems depending upon the soil type, total rainfall and commencement of the rains in the region have to be executed (Table 2) so that soil and water conservation, full utilization of ground water, maintenance of soil fertility is possible.

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. In fact, any cropping system comprising crops with varied maturity period and crop canopy, having high yield potential is today's need in dry land areas where double crop system proved to be potential and cost-effective (Table 3).

Cropping system approach seeks to increase the benefits by crop production from available physical resources with the objective of improved efficiency. Selection of crops and cropping systems in rainfed situations is also determined by the soil depth and available soil moisture in the root zone. The growing

Table 2: Cropping pattern as per commencement of Rains

Period of commencement of rains	Crops to be planted
Second fortnight of June	Pearl millet, groundnut, sunflower, castor, pigeonpea
First fortnight of July	Pearlmillet, castor, pigeonpea
Second fortnight of July	Sunflower, castor, pigeonpea
First fortnight of August	Sunflower, castor, pigeonpea
Second fortnight of August Sunflower, castor, pigeonpea	
First fortnight of September	*Rabi* sorghum as fodder crop

Table 3:Double crop system in Dry land Cultivation

Kharif	***Rabi***
Rainfed	
Pearlmillet/minor millets/rice (upland)/sorghum	Linseed/lentil/rapeseed
Soybean/greengram/blackgram	Safflower/*rabi* sorghum
Sunflower	Chickpea
Limited irrigation	
Pearl millet	Chick pea/safflower
Sorghum/maize/rice	Sunflower/lentil
Sorghum	Chickpea/wheat/mustard/ sunflower
Soybean	Chickpea/wheat/sunflower
Greengram/blackgram	Safflower/*rabi* sorghum
Sunflower	Chickpea
Pigeonpea/cluster bean	Chickpea

Table 4. Crops and cropping systems under soil depth and available soil moisture

Soil depth	Available moisture (mm)	Cropping period (days)	Crops/cropping systems
Shallow	<100	<90	Sole cropping of pearlmillet, sorghum, soybean, pulses and minor millets
Medium	100-150	150	Sole cropping of soybean, sorghum / pearlmillet / soybean / maize/caster + pigeonpea
Deep	>200	>180	Rice-oilseeds / pulses, cotton + soybean, sorghum / maize-chickpea, pigeonpea based cropping system

period of crops facilitate cultivation of intercropping, mixed cropping and double cropping or sequence cropping (Table 4). Intercropping helps to enrich soil fertility, retain soil moisture, reduce the incidence 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. Although cereals gained a marginal increase in area share in the first decade of the Green Revolution, thereafter cereals area and share declined gradually. While cereals and pulses have lost area, the major gainers of this area shift are the non-food grain crops especially oilseeds. 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. The result is an insignificant impact on the growth of the crop output. India having a very wide range of variability in soil types, climate and rainfall distribution which give advantage of having diversified large numbers of cropping patterns. Thus, cropping activities go on round the year if water is available to irrigate the crops. All the cropping patterns have their strength and problems which are briefly described.

Rice–based cropping patterns :

Rice-based cropping pattern is a major cropping system practiced in the country, which include the rotation of crops involving rice followed by mainly wheat, oil seeds, pulses and sometimes maize and vegetables. Various rice-based cropping patterns have been reported from different parts of India ranging from rice-rice-rice to rice followed by different cereals, pulses, oil seeds, vegetables and fibre crops. Rice-based cropping systems may include lowland and upland crops. So far, most people have been focussing on individual crops disregarding the fact that each crop is only a component of a cropping system. The following rice based cropping systems are practiced in India.

Rice–Wheat:

Rice-wheat system is the most prevalent in Uttar Pradesh, Punjab, Haryana, Bihar, West Bengal and Madhya Pradesh states with covering an area of more than 11 million hectares. Despite enormous growth of this cropping system in the country during the past few years, reports of stagnation in the productivity of these crops, with possible decline in production in future, have raised doubts on its sustainability. 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, lack of appropriate varietal combination, shortage of labour during optimum period for transplanting paddy, crop residue management etc.

Rice–Rice:

Rice-rice is the popular cropping pattern in irrigated lands in humid and coastal ecosystems 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 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–Oilseeds/Pulses:

From a view point of food security and national economy, rice-oilseeds/pulses may be considered as the most important cropping system. Mainly mustard, linseed, groundnuts, lentil, lathyrus and pea are grown during winter season rice fallow belt of eastern and southern India. In this cropping system, the yield of rice is satisfactory in all ecosystems, however, wide variations in yield of oilseeds/pulses were recorded from one ecosystem to another. Nevertheless, adoption of appropriate high yielding rice and oilseeds/pulses varieties, adequately supported by improved production technology, ensures desired productivity of the system. Observed gaps suggest that scope exists for at least two fold increases in yields of rice and oilseeds/pulses in the system. In general, with a medium or short duration high yielding rice variety, a successful oilseeds/pulses crop is possible. The oilseeds/pulses crop remains in field up to March and thereafter summer season can be best utilized by another crop to increase the 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. Maharashtra, Gujarat and Uttar Pradesh together have over 4.6 m ha, constituting an additional 1/3 area under pearlmillet in India. Over 66 per cent of this crop is grown in areas receiving 10-20 cm per month of rainfall, extending over 1 to 4 months of the south-westerly monsoon. On the all-India basis, about 20 major cropping patterns have been identified with pearlmillet. 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 groundwater table and build up of diseases/pests and weeds. In pearlmillet-wheat system, farmers are now realizing the need to replace pearlmillet with more remunerative crops. Therefore, diversification may prove to be of paramount importance in several farming situations,

not only in mitigating problems of soil health, but also from economics point of view.

Maize–Wheat:

Maize-wheat crop sequence, 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. This system has a potential to produce food grains to tune of over 10 tonnes/ha per year, however, the maximum yield of maize-wheat sequence was recorded at Palampur has shown a potential of 14.21 tonnes/ha per year. 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:

Sugarcane is grown in about 3.4 million hectare. Uttar Pradesh, Punjab, Haryana and Bihar account for 68% 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 Asom; 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 and imbalance, inadequate use of nutrients, poor nitrogen use efficiency in sugarcane, low productivity of ratoon due to poor sprouting, build up of *Trianthema partulacastrum* and *Cyprus rotundus* in sugarcane and stubble of sugarcane pose tillage problem for succeeding wheat crop and need to be managed properly. Since majority of farmers apply only N in sugarcane and the use of P and K is limited. 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 Uttar Pradesh and black cotton soils of 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% 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 un-sustainability, 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. Introduction of short-duration and Bt cotton varieties have help to contain the cotton–wheat cropping pattern in most of the country.

Legume–based Cropping Systems:

Legume crops generally include pulses and oilseeds and known for their compatibility and suitability in different cropping patterns. Recent advances in the development of large number of short duration and high yielding varieties of pulses and oilseeds have made it possible to include them in irrigated crop sequences. 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 of 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. Nutrient needs of the system have to be worked out considering N-fixation capacity of legume crops.

Conclusion:

The agricultural technology needs to move from production oriented towards profit oriented sustainable farming. The conditions for development of sustainable agriculture are becoming more and more favourable. 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. This will create millions of micro economies with sustainable utilisation of water resources in the water abundant regions. Low-cost water saving technologies will enable the poorest sections of the communities to practice irrigated agriculture with very limited water in water scarce regions.

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WOMEN'S ROLES AND RIGHTS IN WATER CONSERVATION & IRRIGATION

Dr. Sasikala Pushpa, Dr. B. Ramaswamy

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. This new attitude would contribute to build a more just and peaceful world, provided it includes mutual exchange of gender specific knowledge, skills and sharing of opportunities to improve and manage our future limited freshwater resources.

As per Census 2011, the population of India is 1210.19 million comprising of 586.47 million women which constitute about half of the total population. The empowerment of women is fundamental for the progress of the country. The latest census figures list less than 35 per cent women formally as primary workers in the agricultural sector, in contrast to 81 per cent men. However, the indisputable fact remains that India's agricultural industry, which employs 90 to 100 million women, cannot continue to exist devoid of their labor. The women involved in agriculture help in preparing the land, selecting seeds, preparing and sowing to transplanting the seedlings, applying manure, fertilizers, pesticides and then harvesting, winnowing and threshing, they work harder and longer than male farmers. Maintaining the ancillary branches in agriculture sector, like animal husbandry, fisheries and vegetable cultivation, depends almost solely on women. However, their participation in policy making is trivial.

Women have performed and continue to perform a vital role in the conservation of fundamental life support systems such as land, water, flora and fauna. A number of historians believe that it was woman who first domesticated crop plants and thereby initiated the art and science of farming. While men went out hunting in search of food, women started gathering seeds from the native flora and began cultivating those for food, fodder, fiber and fuel. Despite of high women participation in the agricultural work force, 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 liaising with the government administrators vis-à-vis their male counterparts.

The nature and extent of women's involvement in agriculture varies significantly from region to region. Even within a region, their involvement varies widely among different ecological sub-zones, farming systems, castes, classes and stages in the family cycle. Although in spite of of these variations, there is barely any activity in agricultural production in which women does not undertake significant responsibility. Women are 48.5 per cent of the general population of India and agricultural sector is the largest employer of women. According to official statistics, in the rural areas, 59 per cent men work in agriculture, but the figures are 75 per cent for women. Women's participation in agriculture has

been growing relative to men which not only implies increased dependence of women on agriculture, but also reiterates their crucial role in the sustainable growth and future of this sector. Over the years, the movement of men out of agriculture has led to an increase in women's share of the agricultural workforce and an expansion of their role in the sector.

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. This new attitude would contribute to build a more just and peaceful world, provided it includes mutual exchange of gender specific knowledge, skills and sharing of opportunities to improve and manage our future limited freshwater resources. The importance of women for water and water for women was formally recognized in the Dublin Conference. One of the four principles of efficient and effective water provision incorporated into the Dublin Declaration claimed for the full involvement of women in the planning and implementation of all scheme and initiatives for drinking water and sanitation. According to the UN estimates, by 2025 approximately 5.5 billion people, the two thirds of the world's population will face water scarcity. The degradation of water quality worsens the imbalance between water supply and demand. It threatens the sustainability of life in an increasing number of regions throughout the world.

The linkage between environmental degradation and poverty, particularly related to women's life, was recognized at the Conference on the Environment and Development (UNCED) held in Rio in 1992. In this regard, the Rio Declaration declared that the 'women have a crucial role to play in environmental administration and sustainable development. Their holistic involvement is essential to achieve the goal of sustainable development'. Although even after acknowledging this fact that the involvement of women in all phases of water management can benefit water supply and sanitation projects regarding their crucial role in the day-to-day supply, management and use of water, their participation in water conservation programs and their involvement in decision making process still remains to be improved.

Women are the main users of water. They use water for cooking, washing, family hygiene and sanitation. Women play an important role in

water management. The rapid socio-economic and political changes that are taking place at the global level are producing many challenges and problems. It becomes imperative to ensure that the gender perspective is well integrated into policy relating to all sectors of the economy and society including water conservation and irrigation facilities. Due to their significant involvement in collection, usage and management of water in the household. Moreover, as farmers of irrigated and rain-fed crops, women have organic linkage and inherited knowledge about water resources, including quality and reliability, limitations and suitable storage methods and are the key to the accomplishment of water resources development and irrigation policies and programmes.

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 labor and incomes. By raising the value of the land, irrigation brings about social change which usually favors men. Gender analysis can help irrigation planners and policy-makers to improve the performance of irrigation schemes. There are three broad areas in irrigated agricultural production systems that require particular attention, and where a more thorough, gender-based analysis of local situations will help to create more effective, equitable and sustainable irrigation policies and programs. To begin with, ensuring women's right to use and control of land and irrigation water is a primary requirement. Studies have shown a direct correlation between independent land and irrigation rights for women and a higher productivity of land

and labour. 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.

Gender issues refer to any aspect governing the lives of women and men as well as the relations between them. The lack of participation of women in planning, maintenance and management has negative impacts on the quality of the services and on the overall position of women and their participation in development. Gender issues must be integrated into all national policies to achieve equitable development for women and men. In developing countries, the gender issues mean more involvement of women in development and other economical activities. 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. Access to credit will also facilitate women irrigators' access to technology. We need to improve women's skill in water resources management with their active participation. In order to ensure that, we must modify and amend legislations and institutional set-ups to allow women to enhance their role in irrigated agriculture and water conservation. Water and women are both considered to be the source of life by most civilizations throughout our shared history. Now, it is time to acknowledge the need of water for women and women for water.

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Pt. Deen Dayal Upadhayay Vigyan Gram Sankul Pariyojana launched

The Minister of Science & Technology, Earth Sciences and Environment, Forest & Climate Change, Dr. Harshvardhan launched 'Pt Deen Dayal Upadhayay Vigyan Gram Sankul Pariyojana'. This project has been inspired by teachings and ideals of Pt. Deen Dayal Upadhayay whose birth centenary is being celebrated this year. It will endeavour to formulate and implement appropriate S&T Interventions for Sustainable Development through cluster approach in Uttarakhand. Department of Science and Technology (DST) has committed Rs 6.3 crore support for a period of three years for this project. About a lakh of people would benefit directly or indirectly through this project in four identified clusters of 60 villages in Uttarakhand for pilot phase which are located at different altitudes (up to 3000 meters) namely Gaindikhata, Bazeera, Bhigun (in Garhwal) and Kausani (in Kumaon). The adopted strategy would help in creating models that are appropriate for different altitudes and could then be replicated in other hill states as well. The key deliverable in this approach is to utilise local resources and locally available skill sets and convert them in a manner using science and technology, that substantial value addition takes place in their local produce and services which can sustain the rural population locally. Further, the local communities are not compelled to migrate from their native places in search of jobs and livelihoods. Once this concept is validated in the few selected clusters, it can be replicated across large number of village clusters in the country.

Areas of interventions in these selected clusters would be processing and value addition of milk, honey, mushroom, herbal tea, forest produce, horticulture and local crops, medicinal & aromatic plants and traditional craft and handloom of Uttarakhand. Post-harvest processing of Kiwi, Strawberry, Cherry, Tulsi, Adrak, Badi Elaichi through solar drying technology, extraction of apricot oil using cold press technology. Stringent product and process control interventions for energy and water conservation would also be ensured through this project. Practice of agriculture, agro-based cottage industries and animal husbandry in an eco-friendly manner will be emphasized during the implementation of the project. Sustainable employment and livelihood options within the clusters such as eco-tourism, naturopathy and yoga, are also planned to be promoted.

CONSERVING WATER : THE TRADITIONAL WAY

Sanchari Pal

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.

We all know water is essential, but too many of us think it's unlimited. In reality, fresh water is a finite resource that is rapidly becoming scarce. 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.

In addition to these problems, India's burgeoning population makes it especially vulnerable when it comes to water scarcity. Over 300 million people in the country currently suffer from regular water shortage issues, especially in peninsular states. Statistics also 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.

In fact, such was the public suffering caused by dry spells last year that trains carrying drinking water had to be sent to Latur in Maharashtra! This makes the conservation of water a key element of any strategy that aims to alleviate the water scarcity crisis in India.

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.

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. Excavations show that the cities of the Indus Valley Civilisation had excellent systems of water harvesting and drainage. The settlement of Dholavira, laid out on a slope between two storm water channels, is a great example of water engineering. Chanakya's *Arthashashtra* mentions irrigation using water harvesting systems.

Sringaverapura, near Allahabad, had a sophisticated water harvesting system that used the natural slope of the land to store the floodwaters of the river Ganga. 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.

Drawing upon centuries of experience, Indians continued to build structures to catch, hold and store monsoon rainwater for the dry seasons to come. These traditional techniques, though less popular today, are still in use, efficient. Easier to maintain than many modern systems, they are also sustainable in the long run.

Here is a brief account of the unique water conservation systems prevalent in India and the communities who have practised them for decades before the debate on climate change even existed.

1. 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. Jhalaras were built to ensure easy and regular supply of water for religious rites, royal ceremonies and community use. The city of Jodhpur has eight jhalaras, the oldest being the MahamandirJhalara that dates back to 1660 AD.

2. 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. A reservoir with an area less than five *bighas* is called a *talai,* a medium sized lake is called a *bandhi* and bigger lakes are called *sagar* or *samand*.

3. Bawari

Bawaris are unique stepwells that were once a part of the ancient networks of water storage in the cities of Rajasthan. The little rain that the

region received would be diverted to man-made tanks through canals built on the hilly outskirts of cities. The water would then percolate into the ground, raising the water table and recharging a deep and intricate network of aquifers. To minimise water loss through evaporation, a series of layered steps were built around the reservoirs to narrow and deepen the wells.

4. Taanka

Taanka is a traditional rainwater harvesting technique indigenous to the Thardesert region of Rajasthan. 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. An important element of water security in these arid regions, taankas can save families from the everyday drudgery of fetching water from distant sources.

5. Ahar Pynes

Ahar Pynes are traditional floodwater harvesting systems indigenous to South Bihar. Ahars are reservoirs with embankments on three sides that are built at the end of diversion channels like

pynes. Pynes are artificial rivulets led off from rivers to collect water in the ahars for irrigation in the dry months. Paddy cultivation in this relatively low rainfall area depends mostly on aharpynes.

6. Johads

Johads, one of the oldest systems used to conserve and recharge ground water, are small

earthen check dams that capture and store rainwater. 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. Sometimes, several johads are interconnected through deep channels, with a single outlet opening into a river or stream nearby. This prevents structural damage to the water pits that are also called madakas in Karnataka and pemghara in Odisha.

7. PanamKeni

The Kuruma tribe (a native tribe of Wayanad) uses a special type of well, called the panamkeni, 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. These cylinders, four feet in diameter as well as depth, are then immersed in groundwater springs located in fields and forests. This is the secret behind how these wells have abundant water even in the hottest summer months.

8. Khadin

Khadins are ingenious constructions designed to harvest surface runoff water for agriculture. 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. First designed by the Paliwal Brahmins of Jaisalmer in the 15th century, this system is very similar to the irrigation methods of the people of ancient Ur (present Iraq).

9. Kund

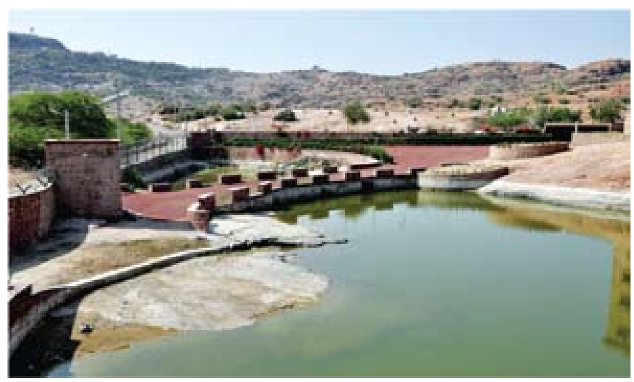
A kund is a saucer-shaped catchment area that gently slope towards the central circular underground well. Its main purpose is to harvest rainwater for drinking. Kunds dot the sandier tracts of western Rajasthan and Gujarat. Traditionally, these well-pits were covered in disinfectant lime and ash, though many modern kunds have been constructed simply with cement. Raja Sur Singh is said to have built the earliest known kunds in the village of VadiKa Melan in the year 1607 AD.

10. Baoli

Built by the nobility for civic, strategic or philanthropic reasons, baolis were secular

structures from which everyone could draw water. These beautiful stepwells typically have beautiful arches, carved motifs and sometimes, rooms on their sides. The locations of baolis often suggest the way in which they were used. Baolis within villages were mainly used for utilitarian purposes and social gatherings. Baolis on trade routes were often frequented as resting places. Stepwells used exclusively for agriculture had drainage systems that channelled water into the fields.

11. 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. Since nadis received their water supply from erratic, torrential rainfall, large amounts of sandy sediments were regularly deposited in them, resulting in quick siltation. A local voluntary organisation, the Mewar Krishak Vikas Samiti (MKVS) has been adding systems like spillways and silt traps to old nadis and promoting afforestation of their drainage basin to prevent siltation.

12. Bhandara Phad

Phad, a community-managed irrigation system, probably came into existence a few centuries ago. The system starts with a *bhandhara* (check dam) built across a river, from which *kalvas* (canals) branch out to carry water into the fields in the phad (agricultural block). *Sandams* (escapes outlets) ensure that the excess water is removed from the canals by *charis* (distributaries) and *sarangs* (field channels). The Phad system is operated on three rivers in the Tapi basin - Panjhra, Mosam and Aram - in the Dhule and Nasik districts of Maharashtra.

13. 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. A water official called a *Chirpun* is responsible for the equitable distribution of water in this dry region that relies on melting glacial water to meet its farming needs.

14. 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. The Kangra Valley system has an estimated 715 major kuhls and 2,500 minor kuhls that irrigate more than 30,000 hectares in the valley. An important cultural tradition, the kuhls were built either through public donations or by royal rulers. A kohli would be designated as the master of the kuhl and he would be responsible for the maintenance of the kuhl.

15. Zabo

The Zabo (meaning 'impounding run-off') system combines water conservation with forestry, agriculture and animal care. 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. The channels also pass through cattle yards, collecting the dung and urine of animals, before ultimately meandering into paddy fields at the foot of the hill. Ponds created in the paddy field are then used to rear fish and foster the growth of medicinal plants.

16. 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. Best suited for crops requiring less water, the system ensures that small drops of water are delivered directly to the roots of the plants. This ancient system is used by the farmers of Khasi and Jaintia hills to drip-irrigate their black pepper cultivation.

17. 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). A full-length bamboo is cut longitudinally and placed on a gentle slope with the lower end leading the water into the jackwell. Often, these split bamboos are placed under trees to collect the runoff water from leaves. Big jackwells are interconnected with more bamboos so that the overflow from one jackwell leads to the other, ultimately leading to the biggest jackwell.

18. Ramtek Model

The Ramtek model has been named after the water harvesting structures in the town of Ramtek in Maharashtra. An intricate network of groundwater and surface water bodies, this system was constructed and maintained mostly by the malguzars (landowners) of the region. In this system, tanks connected by underground and surface canals form a chain that extends from the foothills to the plains. Once tanks located in the hills are filled to capacity, the water flows down to fill successive tanks, generally ending in a small waterhole. This system conserves about 60 to 70 % of the total runoff in the region!

19. 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. The Pat channel then passes through deep ditches and stone aqueducts that are skilfully cut info stone cliffs to create an irrigation system that the villagers use in turn.

20. 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. The tanks are interconnected in order to enable access to the farthest village and to balance the water level in case of excess supply. The eri system enables the complete use of river water for irrigation and without them, paddy cultivation would have been impossible in Tamil Nadu.

There are several other hyperlocal versions of the traditional method of tank irrigation in India. From *keres* in Central Karnataka and *cheruvus* in Andhra Pradesh to *dongs* in Assam, tanks are among the most common traditional irrigation systems in our country.

These ecologically safe traditional systems are viable and cost-effective alternatives to rejuvenate India's depleted water resources. Productively combining these structures with modern rainwater-saving techniques, such as percolation tanks, injection wells and subsurface barriers, could be the answer to India's perennial water woes. After all, we must remember that it is our collective action today that shall determine the course of future.

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India's First Pradhan Mantri Kaushal Kendra for Skilling launched

To bring momentum in skilling through collaborative efforts, India's first Pradhan Mantri Kaushal Kendra (PMKK) for Skilling in Smart Cities was inaugurated in collaboration with New Delhi Municipal Council (NDMC). The foundation was also laid for a Skill Development Centre at Moti Bagh and a Centre of Excellence at Dharam Marg, New Delhi. This event signifies integration and convergence approach towards Respected Prime Minister's two most ambitious projects – the Skill India Mission and the Smart City Mission. Skilled workforce is required for effective development of any big or small project.

The new skill development centres underscore the commitment of the Ministry of Urban Affairs & Housing (MUHA) and the Ministry of Skill Development & Entrepreneurship (MSDE) to support skilling in smart cities. National Skill Development Corporation (NSDC), an executive arm of MSDE, has collaborated with New Delhi Municipal Council Smart City Limited (NDMCSCL) to extend cooperation for setting up of PMKK Centres for Smart Cities, to provide skill training for unemployed youth through its short-term training (STT) module and contribute to the capacity building of municipal employees through Recognition of Prior Learning (RPL) program.

The newly inaugurated Pradhan Mantri Kaushal Kendra leverages NDMC infrastructure for skilling initiatives. Located at Mandir Marg, New Delhi, the NDMC-PMKK Centre for Skilling in Smart Cities is an exemplary heritage building of approx. 30,000 sq.ft., with a capacity of skilling 4,000 youth annually. Catering to healthcare and solar energy sectors, the centre will be managed by one of NSDC's affiliated training partners - Orion Edutech, which has an impeccable record of training nearly 3 lakh candidates through its network of over 275 skill development centres across the country. A solar-power lab powered by Schneider Electric was also inaugurated.

Water in Indian Constitution

India is union of States. The constitutional provisions in respect of allocation of responsibilities between the State and Centre fall into three categories: The Union List (List-I), the State List (List-II) and the Concurrent List (List-III). Article 246 of the Constitution deals with subject matter of laws to be made by the Parliament and by Legislature of the States. As most of the rivers in the country are inter-State, the regulation and development of waters of these rivers, is a source of inter-State differences and disputes. In the 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.

➢ **Article 246:**

- Notwithstanding anything in clauses (2) and (3), Parliament has exclusive power to make laws with respect to any of the matters enumerated in List I in the seventh Schedule (in this Constitution referred to as the "Union List").
- Notwithstanding anything in clause (3), Parliament, and, subject to clause (1), the legislature of any State also, have power to make laws with respect to any of the matters enumerated in List III in the Seventh Schedule (in this Constitution referred to as the "Concurrent List").
- Subject to clauses (1) and (2), the Legislature of any State has exclusive power to make laws for such State or any part thereof with respect to any of the matters enumerated in List II in the Seventh Schedule (in this Constitution referred to as the "State List").
- Parliament has power to make laws with respect to any matter for any part of the territory of India not included in a State notwithstanding that such matter is a matter enumerated in the State List.

➢ **Article 262:**

In case of disputes relating to waters, Article 262 provides:

- 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).

➢ **Entry 56 of List I of Seventh Schedule:**

Entry 56 of List I of Seventh 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 the Union is declared by Parliament by law to be expedient in the public interest".

➢ **Entry 17 under List II of Seventh Schedule:**

Entry 17 under List II of Seventh Schedule provides that "Water, that is to say, water supplies, irrigation and canals, drainage and embankments, water storage and water power subject to the provisions of Entry 56 of List I".

As such, the Central Government is conferred with powers to regulate and develop inter-State rivers under Entry 56 of List I of Seventh Schedule to the extent declared by the Parliament by law to be expedient in the public interest.

It also has the power to make laws for the adjudication of any dispute relating to waters of Inter-State River or river valley under Article 262 of the Constitution.

SUCCESS STORY

JALABHARATHI: PEOPLES' MOVEMENT IN WATER CONSERVATION

Dr. Narayana K. Shenoy

Community has to play a major role in creating awareness among people to conserve water. 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.

The water crisis may be addressed at village/local level and case to case basis in three steps-

1. Creating Water literacy
2. Water awareness and
3. Water conservation

Water Conservation Procession

Water literacy can be brought about through the following ways:

- Knowledge of water resources in and around us.
- Optimum usage of water in our day to day activities involving water.
- To develop the awareness for not polluting the water.
- Prevent leakage of water from taps and pipes.
- Restrict ourselves to use municipal supplied fresh water to clean the premises of schools, office building and roads.
- Reduce the consumption of inorganic materials which pollute water.
- By not creating litter around school premises and public toilets.
- Using small utensils while taking bath.
- While washing clothes and cleaning utensils, do not keep the supply of water running unnecessarily in order to avoid wastage.
- Reuse the domestic waste water for gardening.

Many activities have can be organized to create awareness about judicious usage of water among the public, particularly among school children. These include quiz on water, drawing competition related to water, various public processions out by the school students. Children can be given educational tours to various water sources. Awareness camps can be organised to promote more Greenery in the school campuses and public places.

In addition to these, we can conduct workshops for farmers, teachers and general public regarding importance of water.

The third and last step in this direction is **Water Conservation**. We have encouraged the people to adopt appropriate water conservation methods at suitable places. They are-

- Constructing percolation ponds, recharging ground or open wells and bore wells through rooftop rainwater harvesting structures.
- Showcasing models for rainwater harvesting at schools, houses and temples for public awareness.
- Rejuvenating of defunct open wells/bore wells.

- Maintaining cleanliness in and around public water resources such as tanks, open wells and bore wells.
- Finding out the causes for water scarcity in the region-adopting suitable measures to tackle the issues.
- Rejuvenation of traditional rainwater harvesting structures.
- Use of fewer chemicals in agriculture.
- Less dependence on bore well water and encouraging organic farming
- Planting local samplings to allow the rainwater to infiltrate into ground.


State Level Workshop for Water Conservation

In the last eight years, we have organized 15 state level workshops to train the people in the field of water conservation and awareness. We have conducted about 328 awareness programmes across the state. A total about 1235 teachers, 21731 students and 6994 farmers and general public participated in the programme organized by Jalabharathi.

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National Hydrology Project

National Hydrology Project has been approved by the cabinet on 06.04.2016 as a central sector scheme with a total outlay of Rs.3679.7674 crore [Rs.3,640 crore for National Hydrology Project (NHP) and Rs.39.7674 crore for establishment of National Water informatics Centre (NWIC) as a repository of nation-wide water resources data]. NWIC is envisaged as an independent organization with adequate administrative and financial powers under the overall control of Secretary, MoWR, RD&GR.

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/planning and to strengthen the capacity of targeted water resources professionals and management institutions in India. It is a Central Sector Scheme, with 100% grant to the States, with a Budget Outlay of about Rs 3,640 Crore, along with World Bank Assistance of half of the project cost. This Pan India project will span over 8 years from 2016-17 to 2023-24.

This project will modernize the Monitoring network in project states, with a focus on deploying new sensors, data storage, and telemetry technologies across the whole country, to establish comprehensive, modern, automated, real-time monitoring systems for surface water and ground water. The project will build on the dramatic advances in cloud computing, internet, mobile devices, social media and other communication tools to modernize access to and visualization of customized water information by different stakeholders. The project will develop and demonstrate tools for water resources assessment, hydrologic and flood inundation forecasting, water infrastructure operations, ground water modeling, and river basin and investment planning. The project will complement technology investments with investments in people and institutional capacity. Support will be provided for developing centers of expertise, innovative learning approaches, collaboration with academia and research institutes, and outreach programs. Office and equipment will be modernized to streamline workflows to effectively leverage the technology investments. The project has two groups of direct beneficiaries:

- Central and State Implementing Agencies (IAs) responsible for surface water and/or ground water planning and management, including river basin organizations (RBOs) and;
- Users Of The WRIS Across Various Sectors and Around The World. The ultimate beneficiaries will be the selected farm communities which benefited from pilot projects for water management; rural and urban water and power users; populations affected by floods and droughts, especially poor rural people, and farm families who may benefit from improved irrigation water supply and management; stakeholders across the energy, inland waterways, environment, and agriculture ministries; research and educational institutions; students and researchers; and non-governmental organizations, civil society organizations, and the private sector.

BHAKRA NANGAL PROJECT AND ITS IRRIGATION POTENTIAL

Dr. Amiya Kumar Mohapatra

The Bhakra Nangal Project is a crucial project for the advancement of agriculture especially in the northern parts of the country with Punjab, Haryana and Rajasthan being its major benefactors. Besides providing irrigation for the agricultural practices in these states, the project also has the power generation capacity of upto 1325 Megawatts. On the irrigation wing, it supplies 16 million acre feet (MAF) of water annually in an average for irrigation. This project has resulted in agricultural development through the green revolution as well as contributed towards the milk revolution in the northern states.

Economics of well being rests on economics of agriculture. Empirical evidences show that the amplification of better life of poor is directly associated with the agricultural development. Agricultural sector has a considerable potential in contributing to higher GDP, poverty reduction and inequality reduction etc. India ,to a great extent relies, on agriculture to provide life and livelihood to its people. Even though the contribution of agricultural sector to GDP is less than 13 per cent, still its absolute effect on welfare cannot be underestimated. India's agriculture very much depends upon monsoon and monsoon is pretty uncertain, irregular and uneven. That's why Indian agriculture is called as "gamble of monsoon". It is also observed that about 80 per cent of the total rainfall takes place during the month of June to October. Rainfall during this period remains uneven and causes either a drought or flood situation

Agricultural growth depends upon various factors. Irrigation is one of the most critical factors that fosters agricultural growth by reducing uncertainties. Hence, provision of irrigation facilities is indispensable to enhance agriculture productivity and to ensure better standard of living. Better irrigation facilities will help in meeting the rising food demand created by growing population and in meeting the industry requirements for raw materials. Success of agriculture truly depends upon developed irrigation facilities and further needs to improve water usage to enhance farm productivity. Out of net total arable lands, only 46% land is under irrigation and even the distribution of irrigation facilities across states is highly skewed and scattered. There is also a serious need to minimize the gap that exists between gross cropped area and gross irrigated area. So to promote sustainable agriculture, irrigation is not only essential, but also the need of the hour. Besides, varied crops have distinct water retention capacities and water requirements, that is why irrigation is essential to meet the water need of diverse crops from time to time. Availability of irrigation facilities leads to intensive farming and rotation of crops and augment production to meet the need of 125 crores people and also offer employment opportunities to millions. Irrigation helps the farmers in doing multiple cropping throughout the year and is also needed for overcoming spatial and temporal variations of monsoon.

Types of Irrigation Projects:

On the basis of cultural command areas (CCA), irrigation projects are divided into 3 types:

- **Major Irrigation Projects** are those projects where culturable command areas are more than 10,000 hectares. These irrigation projects are mainly large engineering structures, that are meant to collect, conserve and deliver water to the area where crops are grown. Major irrigation projects are meant to preserve river water and divert the flow and connect it to the large network of canals for irrigation. Besides, these projects also help in controlling flood, generate electricity, fishing etc. Bhakra Nangal Project, Kosi Project, Nagarjuna Sagar Project, Hirakund Project are a few of them.
- **Medium Irrigation Projects** are those projects where culturable command areas are more than 2,000 hectares and up to 10,000 hectares individually.
- **Minor Irrigation Projects** are those projects where culturable command areas are less than 2,000 hectares individually.

Bhakra Nangal Project-Major Irrigation Project:

Government of India has introduced a lot of policy intervention in promoting irrigation since independence. Completion of Bhakra Dam in 1963 was the land mark accomplishment of the Government India. The Bhakra Dam is constructed at a gorge on the river Satluj near the Bhakra Village in Bilaspur, Himachal Pradesh. It is the second highest dam with a height of 225.55m (740 Ft.) next to Tehri Dam. Bhakra reservoir is popularly known as 'GobindSagar' has the capacity to store up to 9340 million cubic meters of water spread over an area of 165.35 km^2. Bhakra Nangal project has the capacity to irrigate 10 million acres cultivable area. The Bhakra Nangal Project consists of both Bhakra and Nangal Dam. Water from the Bhakra Dam further flows to the Nangal Dam. Nangal Dam which is situated about 13kms downstream of Bhakra Dam was designed to ease out the water burden of the Bhakra Dam. It acts as a balancing reservoir to the Bhakra Dam. So the project is known as the "Bhakra-Nangal Dam" even though these are two separate dams.

The Bhakra Nangal Project is a crucial project for the advancement of agriculture especially in the northern parts of the country with Punjab, Haryana and Rajasthan being its major benefactors. Besides providing irrigation for the agricultural practices in these states, the project also has the power generation capacity of upto 1325 Megawatts. On the irrigation wing, it supplies 16 million acre feet (MAF) of water annually in an average for irrigation. This project has resulted in agricultural development through the green revolution as well as contributed towards the milk revolution in the northern states. The water from the dam provides a good network of irrigation facilities across the three states and support the livelihood of millions people.

During 1.10.2015 to 30.09.2016, GobindSagar Reservoir started filling from minimum El. of 474.30 m (1556.11 ft) on 09.05.2016.The maximum reservoir level attained during the period was 503.16m (1650.76 ft) on 15.09.2016 as compared to maximum reservoir level of 511.83m (1679.22 ft) on 28.09.2015 last year. The actual water received in Bhakra reservoir during the period was 16296.74 million m^3 (13.212 MAF) including 4307.31 million m^3 (3.492 MAF) from Beas-Satluj Link and the total water released from Bhakra Reservoir in the same period was 17660.97 million m^3 (14.318 MAF). (*BBMB Report*)

Table 1:

Month-wise Releases of Water (in Cusecs) From Bhakra Reservoir													
Year	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	MAF
2000-2001	15073	20191	27748	23867	22779	21496	16174	18430	17891	15386	14025	12995	13.63
2001-2002	9176	15144	22281	19753	19598	19999	15322	15881	15951	14834	15415	17257	12.08
2002-2003	15676	22082	29528	32199	21157	20463	18803	17449	20703	18503	18326	14876	14.67
2003-2004	11914	22915	29371	32112	27091	23610	16655	17991	19330	17560	16860	19415	15.566
2004-2005	14112	19036	19528	19325	15801	14623	12444	13674	12568	12024	9149	10213	10.522
2005-2006	13591	17517	23496	30254	33345	22612	16465	16063	18466	16353	19199	14783	14.624
2006-2007	13872	24257	32687	22958	27028	21325	14606	15804	16219	16240	12384	12546	14.014
2007-2008	21353	21839	21804	23880	22483	21124	15267	14142	15753	14588	15509	17183	13.749
2008-2009	10019	15975	17890	26613	20553	25113	22235	14947	16704	18176	17244	17521	14.205
2009-2010	11752	22496	29123	27009	19003	16948	12433	14744	14940	15781	16540	15963	13.193
2010-2011	10181	20615	28249	19880	36214	38310	18210	15616	18569	15368	16669	20277	15.721
2011-2012	15677	29449	27833	28098	28503	31287	17544	14159	16241	17319	19736	20574	16.261
2012-2013	13819	20593	27469	25885	21646	17805	13794	14466	15252	15384	12091	16328	13.094
2013-2014	12128	25075	33690	36440	32354	23597	13195	14027	17612	16701	17789	17385	15.848
2014-2015	10848	22581	24311	25797	28261	18965	17620	13916	14601	14199	20327	11550	
2015-2016	9582	21474	30939	32416	36609	20710	15740	13640	16970	15165	18040	16801	
2016-2017	14490	18943	29599	31960	22508	20778	19079	13321	15987	14311	14925	13845	
2017-2018	10436	21347	23358	26915	21865	23083							

The preparation of the water account is done by dividing the year into two parts i.e. the filling period and the depletion period. The filling period is from 21st May to 20th September whereas the depletion period is from 21st September to 20th May of the next year. All the water accounts for the filling as well as the depletion periods are created separately. The filling period indicates towards the period when the dam receives water from rainfall as well as the water from the melting of the snow. The depletion period however, indicates the utilization of the water that was accumulated during the filling period. The share of water is delivered to the various states as per the set processes and agenda (*BBMB Report*). The water supplied to the states during 2014-15 is given below.

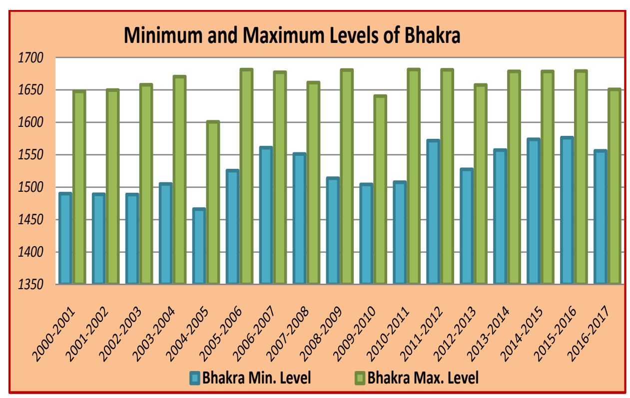
Table 2:

Total Water Supplied to the States from 21/05/2014 to 20/05/2015 (Figures in MAF)						
Project	**Satluj**		**Ravi-Beas**		**Satluj + Ravi-Beas**	
State	**Satluj**	**% Share**	**Ravi-Beas**	**% Share**	**Total**	**% Share**
Punjab	5.191	50.35	6.199	42.16	11.39	45.53
Haryana	3.979	38.60	1.604	10.91	5.583	22.32
Rajasthan	1.140	11.05	6.606	44.92	7.746	30.97
Delhi Jal Board	--	--	0.294	1.99	0.294	1.17
Total	10.310		14.703		25.013	

The rainfall data in the catchment area is typically divided into two parts, one covering the period from June to September while the period from October to May is covered in the second part. The June to September months constitute the major period of rainfall in the northern states making their contribution higher overall. Mostly there is variation found in the amount of rainfall in the area. The amount of rainfall from 2000-01 to 2016-17 is ranges from747 to 1257. There are periods from 2010 to 2015 when this figure crossed the 1000 mark as well. However in the past two years, this figure has reduced to 961mm and 926mm respectively which is a sign of the low rainfall in the area, caused due to global warming and climate change.

Table 3:

Rainfall in Catchment Area (in mm)			
Year	**June to Sept (Bhakra)**	**Oct to May (Bhakra)**	**Total (Bhakra)**
2000-2001	803	210	1013
2001-2002	752	327	1079
2002-2003	692	242	934
2003-2004	854	259	1113
2004-2005	630	117	747
2005-2006	719	226	985
2006-2007	778	364	1142
2007-2008	831	234	1065
2008-2009	1092	165	1257
2009-2010	721	181	902
2010-2011	910	347	1257
2011-2012	845	215	1060
2012-2013	747	357	1104
2013-2014	785	366	1151
2014-2015	635	515	1150
2015-2016	701	260	961
2016-2017	621	305	926



Conclusion:

Nowadays, agriculture sector is facing formidable challenges and a large number of farmers want to quit agriculture as their main occupation. Besides, failure of crops either due to heavy rain or due to draught also adds to their misery. Hence, the government's approach to support agricultural sector will be justified when enough importance is given to irrigation.

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Ministry of Rural Development launches Gram Samvaad App and DISHA Portal

The Ministry of Rural Development has launched the **DISHA Portal** - a smart governance tool developed for MPs and MLAs for monitoring of implementation of various Programmes and Schemes of different Ministries in their constituency through a single portal. Integration of datasets of 41 programmes and schemes of 20 Ministries has already been achieved on this Portal by first week of October, 2017.

To serve and empower the rural citizens of India, by facilitating

The Ministry also launched **Gram Samvaad** - a citizen centric mobile app giving single window access for citizens to information at Gram Panchayat level on various Rural Development programs. The App presently covers seven programs of the Ministry of Rural Development.

In addition to this, 11 Rural Self Employment Training Institutes (RSETI) Buildings and a Plant Phenomics Facility at IARI (Indian Agricultural Research Institute) were also inaugurated.

These initiatives were launched by PM at IARI, Pusa in New Delhi on the occasion of the birth centenary celebrations of Nanaji Deshmukh. He also released a commemorative postage stamp on Nanaji Deshmukh. He said that Nanaji Deshmukh preferred to devote himself towards rural development and making our villages self-reliant, and free from poverty.

The Prime Minister, Shri Narendra Modi visiting an exhibition on theme "Technology & Rural life", on the Birth Centenary Celebrations of Nanaji Deshmukh, at IARI, in New Delhi on October 11, 2017. The Union Minister for Rural Development, Panchayati Raj and Mines, Shri Narendra Singh Tomar and the Minister of State for Rural Development, Shri Ram Kripal Yadav are also seen.

While addressing the gathering, the Prime Minister said that facilities that are associated with cities must also be made available to our villages. He said that the real essence of a democracy is *Jan Bhagidari* (people's participation) and integrating people in the development journey of cities, and villages. Regular interaction with governments is required, he added.

Noting that lack of sanitation facilities is adversely impacting the development journey of villages, the Prime Minister said that is why the Government has been working to build toilets in rural areas.

An exhibition on the theme "technology and rural life" was organised at IARI in New Delhi. The exhibition showcases good practices and applications, as well as schemes and initiatives of the Ministry of Rural Development.

Swachh Bharat Awards on Gandhi Jayanti

On the third anniversary of Swachh Bharat Mission (SBM), Swachh Bharat National Awards were given away by the Prime Minister at a ceremony organised by the Ministry of Drinking Water and Sanitation (MDWS) in New Delhi on October 2, 2017. This day was also celebrated as ***Swachh Bharat Diwas***. Awards were given to winners of essay, film and painting competitions organised as part of *Swachh Sankalp Se Swachh Siddhi* initiative.

The event marked the culmination of a national campaign titled "***Swachhta Hi Seva***" that MDWS had organized in response to the clarion call given by the Prime Minister to citizens of India for their contribution in the improvement of sanitation status in the country in the run up to Gandhi Jayanti.

In his address, the Prime Minister spoke about overcoming the challenges on the way of creating a Swachh Bharat with *Jan Bhagidari*, people's participation. He said that Swachhata cannot be realized even if all political leaders in history came together for it - it can only be realized when 125 crore Indians come together for it. He said that the successes achieved in the Mission so far have not been an accomplishment of the government, but of the people of India who have made this dream of a Swachh Bharat, their own.

He said that until each and every household that has a toilet realizes that Swachhta is their responsibility as well, the vision of a Swachh Bharat cannot be realized. To this end, he said that children and youth are the best ambassadors.

The Prime Minister also spoke about the role played by women in maintaining Swachhta in the household, the need for all members of the family to support them in this task by playing their role.

In the *Swachhta Hi Sewa (SHS)* category, SHS Specially Mentioned Ministry award was presented to the Ministry of Information & Broadcasting, Maharashtra (SHS Specially Mentioned Top State), J&K (SHS Special Award) and Velankanni Church of Tamil Nadu (Specially Mentioned Tourist Place for its work in SHS).

Inter-ministerial awards were also given on the basis of the activities undertaken by the Ministries and Departments in the past three years. These activities were exclusive of Swachhta Pakhwada and Swachhta Action Plans (SAP).

In order to promote cleanliness in and around India's iconic places, a separate category was created to award these places. Iconic places were evaluated on 8 parameters for the work done by them in past one year. Award for the Best Iconic Place went to the Golden Temple, Amritsar. Special awards in the this category were given to Mata Vaishno Devi Temple, Jammu and Kashmir and Meenakshi Temple, Tamil Nadu.

Further, the Ministry of Civil Aviation, Ministry of Railways and the Department of Defence Production were given the Best SAP Ministry Awards. As the Ministries and Departments have been conducting Swachhta Pakhwadas (cleanliness fortnights), a separate category was created for this. The Best Pakhwada awards (for the best 15 days swacchhta activities conducted) were presented to the Department of Health and Family Welfare and the Department of Space. Media has an important role to play in promoting swachhta and making it a mass movement. So, the Media Award was given to Matrubhoomi (Kerala) for contributing in a tangible way in making swachhta a *Jan Andolan* (people's movement).

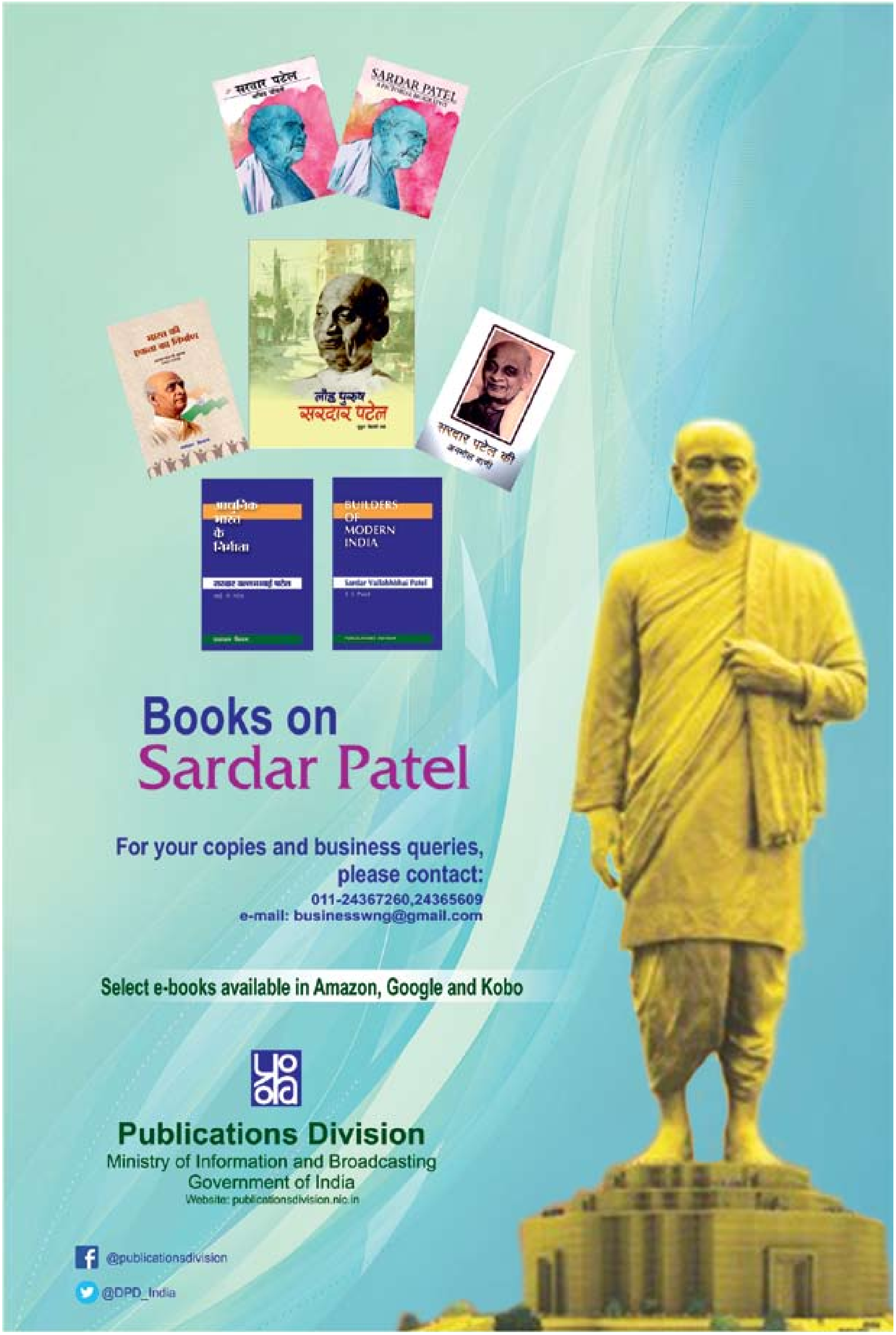
Corporate awards were given to Tata Trust and India Sanitation Coalition for the best support provided to MDWS/SBM for promoting Open Defecation Free (ODF) activity sustainably.

Swachh Bharat (Urban) awards were also presented under various categories to Schools, Colleges, Municipal Workers, Self-Help Groups, Resident Welfare Associations, Religious Institutions etc.

Speaking on the occasion, Union Minister, MDWS, Sushri Uma Bharti congratulated the winners and requested them to continue to inspire others for taking up sanitation initiatives in their area. She shared that the Swachh Bharat Mission has achieved an impressive progress with more than 254,000 villages, 214 Districts, and 6 States been declared open defecation free (ODF) in rural India.

Specially Mentioned Ministry Award to Ministry of I&B

Ministry of Information and Broadcasting (I&B) has played a pioneering role in taking the message of swachhta to the masses since the inception of Swachh Bharat Mission through its various Media Units. In recognition to the work done by the Ministry of I&B, *Swachhta Hi Sewa,* Specially Mentioned Ministry Award was presented to the Ministry of Information & Broadcasting on October 2, 2017. The award was received by Shri N. K. Sinha, Secretary, Information and Broadcasting.



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Rural Development Minister Performs Swachhta Shramdan under Swachhta Hi Sewa

The Union Minister for Rural Development, Panchayati Raj and Mines, Shri Narendra Singh Tomar performed Swachhta Shramdan under Swachhta Hi Sewa initiative in Gwalior on 17th September, 2017. He also participated in tree plantation drive and administered Swachhta pledge to the people. He also flagged off Swachhta Raths to spread awareness about cleanliness.

The Union Minister for Rural Development, Panchayati Raj and Mines, Shri Narendra Singh Tomar planting a sapling, at the "Swachhta hi Sewa" Abhiyan organised in Gwalior.

Speaking on the occasion, the Minister said that positive outcomes have been achieved by the Swachhta message of the Prime Minister. Cleanliness percentage in the country is increasing continuously. Earlier swachhta coverage was just 39 per cent which has now increased to 67 per cent. He said that target is to increase it upto 100 percent with the collective efforts of the Governments and the people.

Nationwide mass movement Swachhta Hi Seva (15 Sept to 2 Oct, 2017) was launched by the President Shri Ram Nath Kovind from Iswarigunj, a village in Kanpur district of Uttar Pradesh. With that the whole country swung into mass Shramdaan for toilet making and cleaning of public places for next two weeks.

The objective of the campaign was to mobilise people and reinforce the "Jan Aandolan" for sanitation to contribute to Mahatma Gandhi's dream of a Clean India. Swachhta Hi Seva campaign saw large scale mobilisation of people from all walks of life to undertake shramdaan for cleanliness and construction of toilets and to make their environments free from open defecation. There were targeted cleaning of public and tourist places. The participation ranged from the President of India to the common citizen and involved Union Ministers, Governors, Chief Ministers, legislators celebrities and top officials. Celebrities, faith leaders, corporate honchos etc. were mobilised to spearhead the campaign in their respective areas of influence.

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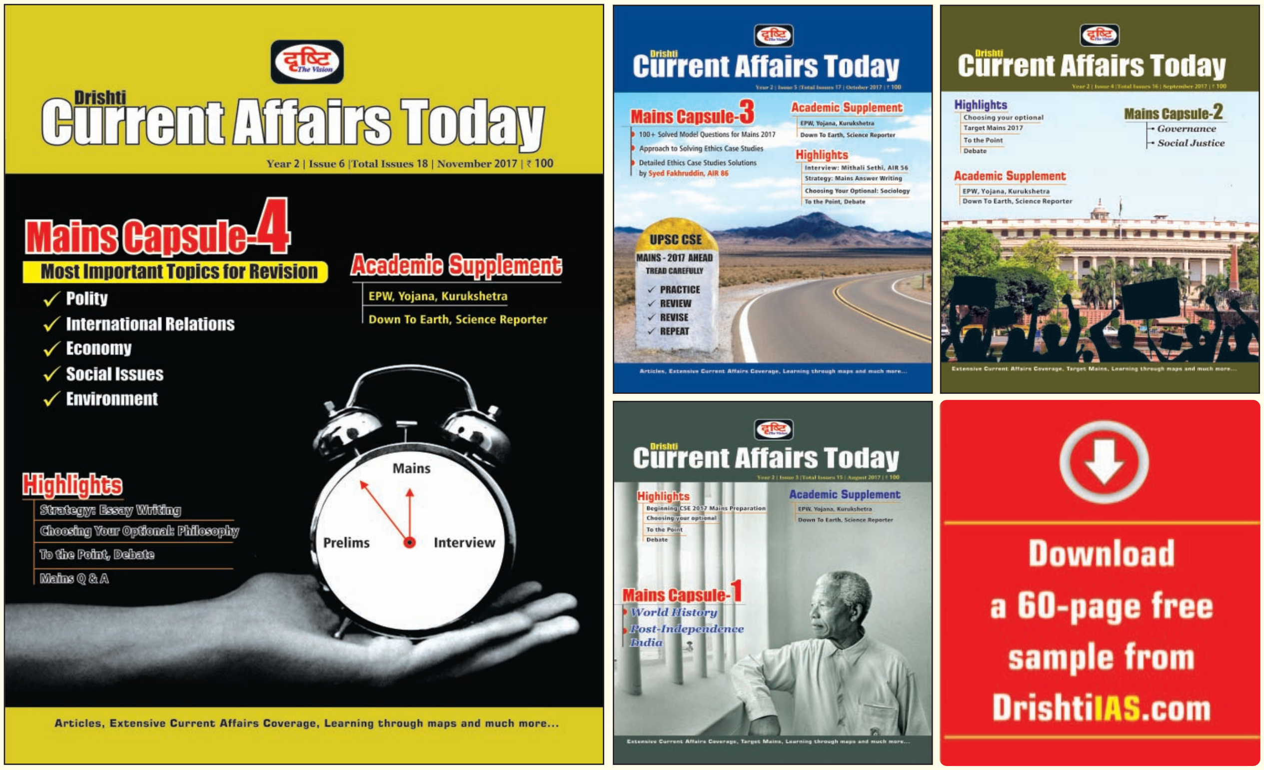

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