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FICCI

ROLE OF PLASTICULTURE IN NEXT GENERATION AGRICULTURE



A Report on

Potential of Plasticulture in India

May 2016

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A Report on

Potential of Plasticulture in India

May 2016

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Message

There is need to encourage the Plasticulture sector to enable it to realize its potential and contribute to the national economy. One of the major sectors of plasticulture application is in the area of water management. Application of micro irrigation can help in increasing productivity by 30 to 100 per cent with significant saving of water. Fertilizer use efficiency is also enhanced.

In the present scenario of depleting water resources, coupled with increased need of food, plasticulture needs to be encouraged. Incidentally this also creates opportunities for the Indian plastic industry as same finds good applications in plasticulture.

I am happy to note that FICCI, jointly with Department of Agriculture Cooperation & Farmers Welfare and Department of Chemicals and Petrochemicals, Government of India is organising a National Conference on Plasticulture. I wish it all the best.

New Delhi
4th May, 2016

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Message

Right usage of water is becoming increasingly important given the fact that India currently supports nearly 17.84% of the world population, with 2.4% land and 4 % of water resources. At the same time, monsoons are also becoming erratic. The resultant is alarming fall in ground water levels placing at risk, the national food security mission. Plasticulture (viz: the use of plastics in agriculture, horticulture, water-management, food grains storage and related areas) is a good answer to this challenge. It can play an important role in facilitating judicious usage of water. It is estimated that appropriate applications of micro-irrigation technologies can result in water saving upto 50-70-%.

It is good that FICCI jointly with Department of Agriculture Cooperation & Farmers Welfare and the Department of Chemicals and Petrochemicals, Government of India is organising a National Conference on "Potential of Plasticulture in India". This is most timely and I wish it good deliberations.

PRABH DAS
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Foreword



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The report on "Role of Plasticulture in next generation Agriculture" is part of Federation of Indian Chambers of Commerce and Industry (FICCI) and TATA Strategic Management Group (TSMG) Chemical Practice's endeavor to assess the industry and end-consumer towards adoption of plastics in the agricultural practices to improve yield and productivity. FICCI & TSMG has been regularly tracking the trends in the plastics and agriculture industry along with the associated industries. The resulting knowledge and experience gives us an additional advantage to prepare this report.

Right usage of water is becoming increasingly important given the fact that India currently supports nearly 17.84% of the world population, with 2.4% land and 4 % of water resources. At the same time, monsoons are also becoming erratic. The resultant is alarming fall in ground water levels. Plasticulture (viz: the use of plastics in agriculture, horticulture, water-management, food grains storage and related areas) is a good answer to this challenge . It can play an important role in facilitating judicious usage of water

Through this report, we have showcased the various Plasticulture methods available for adoption and highlighted the benefits of Plasticulture in farming methods and post harvesting techniques.

We are grateful for the inputs provided by industry leaders as also other stake holders including the farmers, who agreed to interact with us. Their knowledge and guidance helped us shape the report.

The report is a result of FICCI's objective to highlight the potential of plastics in agriculture and business opportunities present in the sector.

Table of Contents



Executive Summary . . . 03
Plasticulture Introduction . . . 05
Significance of Plasticulture in Agriculture . . . 06
Plasticulture Techniques . . . 08
Plasticulture Application descriptions . . . 09
Types of Plastic in Agriculture application . . . 15
Plastics Application in Post Harvesting . . . 16
Plasticulture Potential . . . 18
Progress of Micro-Irrigation . . . 19
Reason for adoption of technology . . . 21
Reason for Non-adoption. . . . 22
Measure to tackle the challenges . . . 23
Case Study I: Israel . . . 25
Learning . . . 27
Case Study II: China . . . 28
Case of Bio-degradable plastic . . . 30
Conclusion . . . 31

Articles

Indian Agriculture under a Severe Water Stress: Ushering Prosperity through Water Security By Dr. Bhart R Sharma . . . 32
Per Drop More Crop: It's now or Never by Mr. Puneet Singh Thind . . . 41
A Window to Plasticulture by Mr. P S Singh . . . 44
References . . . 49
About Tata Strategic. . . . 50
Tata Strategic Contacts. . . . 51
About FICCI . . . 52

LIST OF FIGURES AND TABLES

Figure 1: Potential growth in Agriculture-GDP (INR Cr.) by Plasticulture, FY13 07

Figure 2: Negative effect of Plastic Mulches in China 29

Table 1: Major Plasticulture Applications. 08

Table 2: Polymers used in Plasticulture applications 15

Table 3: Post-Harvest Operations. 17

Table 4: Potential of Plasticulture applications 19

Table 5: Plasticulture progress in India (2013) 19

1

Executive Summary



India supports nearly 16% of world's population with 2.4% land resource and 4% water resource and lately the dwindling quality and the vagaries of the availability of these resources are raising serious questions on the sustainability of the agricultural practice. To counter the problem, efforts need to be redirected to improve the productivity of the land, efficiency of the supply chain while reducing the carbon footprint, by efficient usage of fertilizers, as a result of agricultural practice. Plasticulture, which is use of plastic in agricultural practice, is an answer to this rallying cry. Plasticulture is a scientific way of carrying out agriculture, which not only improves the productivity, but optimizes the input resources as well, thereby reducing the cost.

There has been significant progress in the adoption of Plasticulture techniques in the last decade, however the low penetration levels suggest it needs to grow at a rapid pace from now. On the demand side awareness of the available options and subsidies, its relevance and applicability could improve the adoption rate. From the supply side industry needs to take efforts to bring down the capital cost, work on creating an environment where Plasticulture culture is a norm than exception. Concentrated efforts in direction of demonstration, spreading word of mouth, and building credibility by performance & after-sales services could help shape the industry.

Government policy intervention in creating the environment for investments in R&D, supporting farmers with initial subsidies as per the local conditions and

improving the timelines for sanctions of subsidies would be important to shape the structure of the industry. There are enough cases of successful implementation of these measures elsewhere and subsequent value creation to all the stakeholders across the value chain. It is becoming increasingly clear that this technique remains, no more a choice but the only option, if we have to remain self-sustainable in our food security.

We are at the cusp of changing paradigm in agriculture and it is an opportunity we have to tame efficiently and swiftly.

A second phase of Green Revolution is in making... or is it.

2

Plasticulture Introduction



Use of plastic material in agricultural practices is referred to as Plasticulture. Plasticulture includes all kinds of plant or soil coverings ranging from mulch films, row coverings, poly-tunnels to greenhouses. The benefits of Plasticulture are reduced water loss, UV stabilization to cool soil and prevent insects & prevention of weed growth. Polyethylene plastic film is used majorly for Plasticulture, by growers, because of its flexibility, easy manufacturing and affordability.



3

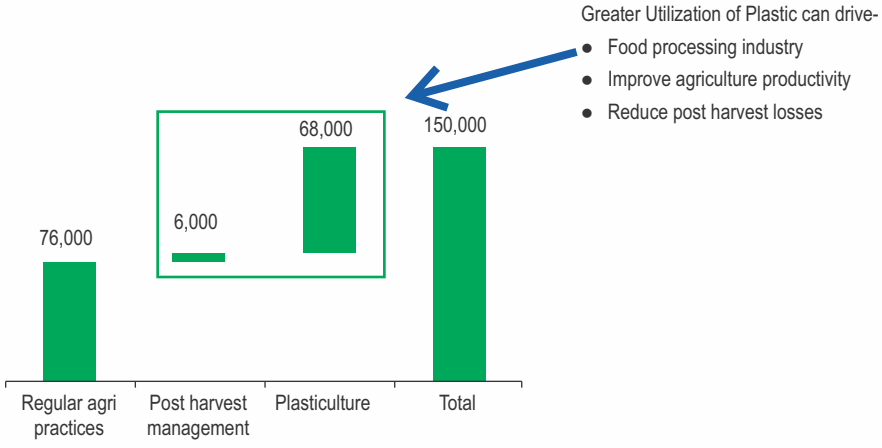
Significance of Plasticulture in Agriculture

India currently supports nearly 16% of worlds' population with 2.4% land resources and 4% water resources. The net sowed area in India stands at 141.3 million Ha and the net irrigated area is 63.2 million Ha (45%). Monsoons are the primary source of irrigation in India as the three-fifth of the land is irrigated directly by rainfall. To irrigate these land, India receives three fourth of its rains, in just four months of the year. In recent years the average amount of rain received has declined and variability also has increased. Ground water table has fallen more than 4 meters during last two decades and in some regions, of high agricultural productivity, it is falling at rate on one meter per annum. As per estimates by 2025 about a third of India would be under absolute water scarce condition. Water availability for irrigation is expected to come down from ~82% in 1997 to ~72% by 20251. Distribution of water remains a concern as three-fifth of the water is lost in conveyance and about half of the losses happen through seepage. These and other factors contribute to a wide gap in crop productivity in India which stands at ~40-60% of world's average while raising serious questions on sustainability of agriculture and eventually on food security. There is also heavy pre and post-harvest losses which further contribute to low availability of food grains and fruits and vegetables. All these factors make use of plastics in agriculture an interesting proposition, as there are substantial benefits of employing the Plasticulture techniques to improve the productivity while saving the water consumption and minimizing the post-harvest wastages. Compared to world average of polymer

utilization in agriculture which stands at 8%, India has ploymer utilization of just 2%. Hence there is a lot of potential of plastic application in agriculture.

The greater use of plastic in agriculture can also help to a great extent to achieve up to fifty percent of the intended targets in Agriculture (as shown in the figure 1). The wider use of Plasticulture can reduce the loss of harvest and can increase the efficiency thus contributing more to the GDP. It is estimated that the agriculture output can be increased by ~INR 68,000 Cr by using proper Plasticulture applications like drip irrigation, mulching etc. Also, using innovative plastic packaging and handling techniques can promote proper harvest management which will in turn contribute towards the Agriculture-GDP.

Figure 1: Potential growth in Agriculture-GDP (INR Cr.) by Plasticulture





4

Plasticulture Techniques

Table 1: Major Plasticulture Applications

Application	Comments
Drip Irrigation System	• Precise application of irrigation water and plant nutrients at low pressure and frequent intervals through drippers/ emitters directly into the root zone of plant
Sprinkly Irrigation	• Application of water under high pressure with the help of a pump.
System	• Water is released through a small diameter nozzle placed in the pipes
Ponds and Reservoir	• Plastics film lining to prevent against seepage in canals, pond reservoirs
Linings	• Also avoids depletion of stored water used for drinking & irrigation purpose Mulching is covering the soil around the plant with plastics film, straw, grass, hay, dry leaves, stones etc.
Plastic Mulching	• Prevents loss of moisture and acts as a barrier between the soil and atmosphere
Greenhouse	• Greenhouse is a framed structure covered with glass or plastics film Acts as selective radiation filter, in which plants are grown under the controlled environment
Plastic Tunnel	• Plastic tunnel facilities the entrapment of carbon dioxide, thereby enhancing the photosynthetic activities of the plant that help to increase yield

5

Plasticulture Application descriptions



Plastic Mulch

In this technique crops grow through the holes in the thin plastic sheets. This used in conjunction of drip irrigation is used mainly to conserve water and suppress weeds. Certain mulches act as barrier to keep Methyl bromide, a powerful fumigant & ozone depleting agent, in the soil. Disposal of plastic mulch is a concern; however technologies exist to recycle mulch into reusable resins.

Benefits:

- *Early planting and faster growth*: Dark and clear mulches intercept direct sunlight thereby reducing soil temperature, hence facilitating early faster growth.
- Soil moisture retention: Plastic mulches reduce the water loss due to evaporation which means there is less water requirement for irrigation and even distribution of moisture reducing plant stress.
- Weed management: Plastic mulch prevents weed growth by preventing the sunlight from reaching the soil & by blocking the pathway for the weeds to grow.
- Optimizing fertilizer usage: Drip irrigation with plastic mulch reduce the leaching of fertilizers below root zone thereby ensuring that the nitrogen and

other nutrients are applied only to the root zone as needed. This greatly reduces the fertilizer requirement as compared to broadcast fertilization with flood & furrow irrigation.

- Crop quality: Plastic mulches reduce contact of fruits and vegetables with soil thereby reducing fruit rot and keeping the produce clean.
- Better Soil aeration: Plastic mulch reduces crusting effect of rain and sunlight and quantity of weed resulting in better soil aeration and aiding microbial activity.
- Root damage reduction: Reduction in weed eliminates the need of cultivation ensuring lesser root damages and improving overall growth of plant.

Disadvantages:

- Cost: plastic mulch comes at a much higher cost as compared to bare soil planting. The cost components include equipment, plastic film, trans-planters for plastic beds and additional labor for installation and removal of films.
- Environmental concern: Conventional plastic, used as mulch film tend to accumulate in soil as the disposal of these are economically and technically difficult. Biodegradable plastics are a good substitute as they get eventually degraded by microbial community.

Lettuce on Plastic mulch



Plastic mulch inline



Colored plastic mulch



Drip Irrigation

Drip irrigation drips water slowly to the roots of the plant, either through the soil surface or directly on the root zone. A narrow tube delivers water directly to the plant base.

Benefits:

- Reduced labor: Labor cost is very less compared to conventional irrigation and is further reduced as activities like field leveling is no longer necessary in drip irrigation.
- Better water utilization: Water application efficiency is very high with flexibility of using recycled non-potable water, while providing a uniform water distribution and maintenance of moisture within the root zone at field capacity.
- Reduced cost: Reduced leeching results in better utilization of fertilizers and operating generally at lower pressure results in energy saving too. As foliage around plants is dry, it reduces the risk of plant diseases too.

Disadvantages:

- High installation cost: There is high initial cost of installation and if the water has high salinity/ alkalinity, the field soil might become unsuitable due to salinity and poor infiltration of the soil.
- Requires proper maintenance: The sun affects the tube and associated systems and equipment, if not properly maintained, might result in clogging.

Online Drip Irrigation



Inline Drip Irrigation



Sprinkler Irrigation

Sprinkler irrigation is a method of applying the irrigation water by spraying it in the air through sprinklers so as to break it up into small drops before falling to the ground.

The pump system, sprinkler and operating parameters must be designed for uniform application.

Benefits:

- Protects crops against frost
- Saves crops from insects & pests
- Irrigation is possible on undulating terrains

Online Drip Irrigation



Inline Drip Irrigation



Semi-Permanent system



Rain-gun sprinkler system



Farm Pond with plastic film

Rainfall in drought prone areas is highly erratic, which makes storage of water an integral part of rainwater harvesting system. The water seepage and evaporation are major challenges in these areas due to which drop in depth per day of ponded water is high. To escape this depletion of stored water, pond sealing is done by installing it with conventional plastic lining. It reduces the seepage in effective and cost economic way. Different lining materials are available in the market, which includes concrete, HDPE (high density polyethylene), PVC (polyvinyl chloride) and polyethylene.

Benefits:

- Conserves water for supplementary irrigation
- Suitable for low rainfall areas
- Use of Saline water is possible

Geo-membrane Farm pond **Canal Cover** **LDPE pond cover**





Greenhouse

Greenhouse is essentially a structure built using transparent materials, such as plastic or glass, in which regulated climatic conditions are simulated to help crops grow. The climatic simulation is aided by equipment such as screening installations, heating, cooling and lighting. Typical plastics used for greenhouses are polyethylene film, polycarbonates and Poly methyl methacrylate acrylic glass.

Benefits:

- Quality of the produce is of superior standards
- Provides better control on pests and diseases
- Crop maturity is early, making room for more crops

Shade nets

Shade nets are a framed structure made of materials such as bamboo, wood, iron, etc. Structurally being similar to greenhouses, it is covered with plastic nets having different shade percentages. Each plant has its distinct requirement for sunlight and shade under which it grows best. Simulating the optimum growth conditions requires selection of the correct percentage of shade factor. Round the year

cultivation is made possible by partially controlling atmosphere and environment by reducing light intensity and effective heat during daytime.

Benefits:

- Better yields during summers
- Reduces evaporation losses
- Cuts down the sunlight intensity to protect plant saplings

Low Tunnels

Low tunnels enable crop production in the cold climates, plains and during rains. Being similar to greenhouse, polyethylene films have proved to be highly economical and effective in controlling conditions to support plant growth.

Benefits:

- Improved quality and quantity of produce
- Reduction in the incidence of disease and pests
- Faster growth and maturity of crops due to controlled conditions
- Use of water is optimized and there is a reduction of 40-50%

Soil Solarisation

Soil Solarisation is a technique of using solar energy to control weed growth and soil borne pests such as plant pathogens including bacteria, insects & mites. This is done by mulching the soil with a transparent polyethylene cover to trap the solar energy. Soil is decontaminated using solar power as a pre-planting soil treatment. Solarisation induces biological, chemical and physical changes in the soil inducing increased growth response & long-term effects on biological control.

Benefits:

- Kills insects and soil borne pests
- Control weed growth
- Controls nematodes

6

Types of Plastic in Agriculture application



Table 2: Polymers used in Plasticulture applications

S. no	Applications	PVC	LDPE	LLDPE	HDPE	PP
1	Drip Irrigation	Main/sub main lines	-	Laterals/ emitting pipes	Screen filter	Drippers/ emitters
		Control valves	-	Micro tubes	Disc filter	Fittings
2	Sprinkler irrigation	Main/sub main lines	Connecting line	-	Main/sub main lines	Fittings
		Control valves	-	-	Nozzles	Nozzles
3	Greenhouse	Main/sub main lines	UV films	UV films	Main sub main lines	Ropes
4	Low Tunnel	-	UV films	-	Hoops	Ropes
5	Mulching	-	-	UV films	-	Non-Woven
6	Piped Conveyance	Main/Sub main lines			Main/Sub main lines	
7	Sub surface drainage	Main/Sub main lines				Envelope material
8	Shade house	Main/Sub main lines			Shade nets	
9	Plant protection nets				Nets	
10	Soil Solarisation		UV films			
11	Lining	Film	Film	Film		Non- woven
12	Banana/Fruit covers					Non- woven
13	Unit packaging			Thin wall containers	Leno/crates	Punnet/ crate

Source: *NCPAH*



7

Plastics Application in Post Harvesting

India is a country with a large population with huge food requirements. Unfortunately, about 20-30% of the fruits and vegetables produced in the country are lost due to mismanagement, wastage and value destruction. So, a sizable chunk of the harvested product is lost before reaching its end-consumer. There is a huge potential to save this sizable fraction and improve the system. Lack of sorting facilities, inappropriate packaging, slow transport systems and inadequate storage facilities are some of the key factors behind this loss of perishable goods.

Plastics have the potential to play a significant role in preservation of quality and longevity of harvested produce.

Application

The value chain of the post harvesting process for both perishables and durables are described in the table below.

Table 3: Post-Harvest Operations

PERISHABLES	DURABLES
1. Field Handling	1. Field Handling
2. Receipt	2. Threshing
3. Conveying	3. Receipt
4. Cleaning	4. Pre-cleaning
5. Sorting	5. Drying
6. Grading	6. Storage
7. Treatment	7. Transport
8. Packaging	8. Receipt
9. Unitization	9. Cleaning
10. Storage	10. Treatment
11. Dispatch	11. Storage
12. Transport	12. Processing
13. Wholesaling	13. Retailing
14. Retailing	14. Consumption
15. Consumption	

Source: *TATA Strategic analysis*

Effective post-harvest management includes good quality storage infrastructure, bulk handling tools and creating the necessary infrastructure across the value chain. Plastics are used to make crates, seals, etc. which make the handling and packaging of the harvest easy.

Benefits

- Storage of the harvest helps extend the shelf life of the product.
- Minimizes the moisture loss from the product by increasing the humidity in the storage room and around the product.

Advantage

Plastics are easy to handle, cheap, durable for long period and inert with most items, all of which make plastics a sustainable choice over its substitutes such as paper, cloth, etc.



8

Plasticulture Potential

India is a vast nation. Every region has got specific agricultural characteristics and problems. These specific problems of the area could be tackled with tailored innovative and scientific use of Plasticulture techniques. This would not only maximize the output of farms but also optimizes the input factors. Table 4 shows the region specific constraints in agriculture. For example, in Western Himalayan region the productivity is low because of constraints like severe soil erosion, degradation due to heavy rainfall/floods and deforestation and inadequate market delivery infrastructure.

Each Plasticulture application can drastically save water by about 30 to 100%. In case of farm pond lined with Plastic film the total loss by seepage of water can be minimized, almost to zero. Also, efficient use of fertilizers can bring the costs down which again is beneficial for the farmers.

Table 4: Potential of Plasticulture applications

Plasticulture Application	Water Saving (%)	Water Efficiency (%)	Fertilizer Use Efficiency (%)
Drip Irrigation	40-70	30-70	20-40
`Sprinkler irrigation	30-50	35-60	30-40
Plastic Mulching	40-60	15-20	20-25
Greenhouse	60-85	20-25	30-35
Shade Nets	30-40	30-50	Under Trial
Tunnel	40-50	20-30	Under Trial
Farm Pond Lined with Plastic Flim	100	40-60	Under Trial

Source: *NCPAH*

Table 5: Plasticulture progress in India (2013)

S. No.	Plasticulture Application	Area Covered ('000 ha)	Potential Area ('000 ha)	Penetration Level (%)
1	Drip Irrigation	2,076	34,915	6%
2	Sprinkler Irrigation	2,169	45,790	5%
3	Greenhouse & Plastic Tunnel	20	700	2.8%
4	Shade Net	30	1,000	3%
5	Plastic Mulching	30	1,000	3%
6	Plant Protection Nets	20	1,203	1.6%

Source: *NCPAH, NMMI Report*

Progress of Micro-Irrigation

India has been taking the Micro-Irrigation way. Micro Irrigation methods have been found to have a significant water saving and crop productivity benefits. In areas with lack of water sources, like Israel, which is a water scarce country, drip irrigation has been followed to achieve water self-sufficiency by improving water used per ton of output (hectare irrigated) due to improvements in water use efficiency in agriculture. Micro Irrigation market in India is Rs. 1,398 crores has grown at 20.5% over the duration (FY'07 – FY'13) as compared to the global market which has grown at 18%. During the period 2008-2012, areas covered under drip irrigation and

sprinkler irrigation has grown at a CAGR of ~63% p.a. and ~74% p.a. respectively in India. While there has been good growth, there is a lot of potential for the future. Penetration level of Micro-irrigation methods has been 5.26 % of the potential irrigated area. The progress of micro irrigation industry has been supported by the entry of MNCs such as John Deere, Netafim, Azud, Plastro, Finolex Naandan, Emtelle, Adritec, Automat, etc. along with the joint venture created between Mahindra & Mahindra and Godrej Agrovet.

As per the 12th five year plan by the government of India, 100.8 lakh hectares of land is expected to adopt micro-irrigation methods with drip irrigation covering ~48 lakh hectares and sprinkler irrigation covering ~53 lakh hectares of area. This estimated rise in adoption of micro-irrigation methods will raise domestic plastics consumption by ~1537 KT, with polymer requirement for PE, PP and PVC of 1156.4 KT, 47.6 KT and 333.2 KT respectively.

9

Reason for adoption of technology



As per the farmers the priority order for benefit realization and hence adoption is as follows:

- Water saving (> 20%)
- Time saving
- Labor saving (7.5% - 18.75%)
- Fertilizer saving (~ 28%)
- Higher production (~42%)
- Proper utilization of land (Irrigated land increase: ~ 8.5%, Reclamation of waste land: 3.5%)
- Quality of produce
- Early fruiting (7-21 days)



10

Reason for Non-adoption

The non-beneficiaries farmers cited following reasons for not adopting this technology.

- High capital cost
- Lack of technical knowledge
- Lack of awareness regarding subsidie
- Perception that the system is not required or the system is not economical, therefore not required for the cropping pattern adopted by them.
- Some farmers also reported that though they have applied for the subsidy grant but are yet to receive the sanction.

11

Measure to tackle the challenges



Scheme related

- Schemes should be made available as per the requisite condition of the field and environment. A uniform standardized subsidy policy fails to address the respective issues for specific segments.
- The implementation is carried out by parallel departments, who do not pay adequate attention to the crops of other departments. The best implementation strategy is emulation of the Special Purpose vehicle (SPV) implemented in Gujarat and AP.

Technology related

- Central testing facility must be established to deal with the design, development & testing of equipment. Government should conduct regular random audit with at least 2% of the beneficiaries within first year of installation, to ensure that suppliers supply good quality installations.
- Warranty & After-sales services ought to be monitored by implementing agencies and balance of payment on basis of satisfaction of the beneficiary should be considered and evaluated.
- Standardization of components must happen as availability of fungible spare part is an issue.

Awareness & Capability building

- Current extension network is not making significant impact in creating awareness. Involving system manufacturers would increase the existing quality of the existing network.
- System manufacturers must carry out frequent demonstration at strategic locations for creating awareness and be involved in providing agronomic packages to encourage adoption.
- System suppliers are as effective as Word of Mouth in creating awareness so they must be involved in demonstration to potential beneficiaries. Technical and operational aspects should be mandatory part of training by system suppliers.
- It is understood that the field officials involved in GOI scheme have inadequate knowledge. Refresher course and exposure visits are required to enable them to deliver the implementation.

Follow up action

- The potential of these practices are yet to be mapped in the states. If the potential is mapped, targets for the same could be fixed and project management efficiency and efficacy could be tracked.
- High initial cost of installation for Micro irrigation is one of the major reasons for disinclination of farmers to adopt the technology. 1% of the MI outlay must be earmarked for R&D and the existing low cost technologies must be popularized for scale up and adoption.

12

Case Study I: Israel



In Israel in the year 1984 some visionary farmers took initiatives to work in the direction of sustainable agriculture. Cost of fresh water at the time was only 6 cents per cubic meter, so neither the government nor the water company, were interested to pursue the idea further. These farmers however were convinced of the impending water crisis; hence they started spreading awareness about peer group and collected $500,000 to kick-start reclaimed water management. Only after one year of preparation of the detailed plan the banks agreed to give a loan of $700,000. As the project was rolled out, government and water company joined the association to create an environment conducive for a sustainable agricultural practice. The critical dimensions of the program are as follows:

Water Rights & Allocation

- Each family farm has fixed entitlement of 14,000 m3/year
- Every cubic meter of fresh water that the farmer trades for reclaimed water, earns a 20% supplement of reclaimed water

Financing & Variable cost

- 40% of capital cost for reclaimed water irrigation is funded by the government
- 40% of the variable cost of reclaimed water is covered by the government subsidies

- Slab wise rates for fresh water entitlement usage incentivizes farmers to switch to reclaimed water

Water Service

- Extension Service specialist provides inputs on nutrition, on basis of monthly analyses, to reduce fertilizer application
- He collects data and tests water, soil & crop response to reclaimed water
- Control center offer partnership to operate & manage irrigation system

Water Distribution

- As per installed system reclaimed water is available at head of field
- Reservoirs help in better regulation & flexibility as water can be stored for lean periods
- Automated online systems gives alarm signals on mobile phones of any disruptions to users & technicians

Governance

4 agencies separately focus on:

- Supply of reclaimed water
- Improve reclaimed water quality by technology improvement for desalination
- Extension of orchard area as potential areas for reclaimed water irrigation
- Environmental protection & identify economical options

Training

- Regular trainings are arranged by the extension service
- Knowledge transfer and next steps are discussed in the meetings between association representatives & the leading farmers
- Such concentrated and coherent efforts have resulted in sustainable agriculture model which needs to be emulated elsewhere in the world.

Learning

- Right companies or financial agencies must be identified as partners, by associations, depending upon type of development
- Appropriate support services systems must be provided for technical know-how
  - Technical support for the operation and maintenance
  - Professional advice through the extension service
- There must be a mechanism for learning from the field by tracking the performance of the systems at ground level
- All the members in the association must have direct and common interest of benefits for efficient functioning
- Inclusiveness of farmers ensures appropriate attention to their needs in planning and implementation



13

Case Study II: China

China since 1990's has been implementing the usage of plastic mulch to solve the problem of food security and water scarcity. As a result the application of plastic in agriculture has increased from 319000 tonnes in 1991 to 1245000 tonnes in 2011. The growth rate is likely to continue to be 8-10% in the next decade. Area cover under plastic mulching has increased from 5 million hectares in 1991 to 20 million hectares in 2011 and would cross 30 million hectares by 2021. This and other initiatives have result in better yields and water use efficiency.

Positive Impact

- B Maize, wheat, cotton and potato yields increase by 33.7, 33.2, 26.1 and 36.7%, respectively
- Water-use efficiency levels increase by 38.9, 30.2, 30.2 and 37.8% respectively

However, with improved efficiency, there are environmental problems which are cropping up and what was termed as "White revolution" is getting transformed to "White pollution”

Table 2: Negative effect of Plastic Mulches in China



Negative Impact

- Plastic majorly made of PVC doesn't degrade in soil
- Degradation is leading to formation of hazardous chemicals
- Residual plastic is affecting the crop productivity eg. Cotton yield reduction by 15%

The solutions to these environmental concerns are being discussed and worked upon.

Solutions

- Better quality plastic would ensure intactness in use and mechanized recovery
- Biodegradable plastic solutions are being developed by scientists
- Development of light-weight, simple machinery is required for recovery of residual mulch film.

Case of Bio-degradable plastic

One of the major reasons for non-adoption of Plastic mulch, at a rapid scale, in the farms, is that the mulch is seen as a pollutant in agronomy and there are associated problems with the adoption, implementation and recovery of the plastic from the field.

Plastics from PVC don't degrade, and even if it does, it leads to release of hazardous chemicals. Recycling is also restricted as the mulch gets contaminated with soil or agrichemicals, equipment is unavailable for baling, and the facilities for recycling are long distance away.

An interesting solution to this problem is the use of biodegradable plastic instead of the PVC grade. These plastic grades mineralize fully into carbon dioxide and water. Commercially available mulches are made from plant starch, however due to the brittleness of the starch; it must be blended with other polymers. These mulches are finding application in Canada and European Union. Starch based products in the market include Biomax TPS (DuPont, USA), Biopar (Biop, Germany), Paragon (Avebe, Netherlands), BiosafeTM (Xinfu Pharmaceutical Co., China), Eastar BioTM (Novamont, Italy), Eco-Flex® (BASF, Germany), Ingeo® (NatureWorks, USA) and Mater-Bi® (Novamont, Italy).

Polymers made from polylactic acid (PLA) and polyhydroxyalkanoate (PHA) have great promise for future as these are versatile and made from completely 100% renewable sources (corn and sugar beet starch). New experimental mulches are being prepared from PLA and PHA using new technologies.

An interesting alternative to bio-plastic is biodegradable paper, which is currently being used as a substitute in Finland and Egypt.

14. Conclusion

India is at a crucial juncture when it needs to tackle the issue of food security by optimizing the use of resources, which traditionally has been taken for granted. Plasticulture is a viable solution for India, to launch 2nd Green revolution. The paucity of water, lower productivity and inefficient use of fertilizer leading to higher carbon footprint can all be taken care by efficient use of Plasticulture. On the demand side, awareness about the possible benefits and subsidies available could help in the adoption of technology. On the supply side, effort needs to go in creating the awareness through demonstration, build credibility by post-installation management, technology advancement to bring down the capital cost and develop viable bio-degradable alternatives thereby improving the productivity while reducing the carbon footprint.

Government needs to create an environment by promoting the Plasticulture by easy and efficient sanction of subsidies and promoting investments by allocating a share of agriculture budget to R&D. It is important we leverage the knowledge bank, which exists in the Indian institutes and tacit understanding of extension services today, to develop tailored solutions as per the local conditions and while also incorporate learning from other economies. The concentrated effort would ensure that the growth rate remains sustainable in following years, as the current penetration level are quite low. With a systematic industry approach supported by policies and government, we indeed could trigger the 2nd Green revolution.

15. Indian Agriculture under a Severe Water Stress: Ushering Prosperity through Water Security

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Access to clean, safe and secure water supplies in India is crucial to all types of planning- rural and urban development, environment and health issues, poverty alleviation, and biggest consumer of them all, agriculture (Furtado, 2016). And in the current year of 2016 all these sectors and stakeholders have been hit hard. More than 330 million people living in 254 of 678 districts in the country are under the spell of drought. The crisis seems to be unprecedented as 'water trains' ferry water to the parched lands in Maharashtra, women and children carry head loads of water from distant locations sometimes scavenging from deep holes and gorges, armed musclemen protect the water ponds in Bundelkhand, police officers escort water tankers following cases of violence over water relief distribution and even cricket matches are relocated through court directions. The most distressing is the spurt of hydro-suicides where small and poor farmers cannot withstand the withering of their cash crops where they have put all their might and borrowed resources. The hardest hit are the states of Maharashtra, Madhya Pradesh, Karnataka, Uttar Pradesh and Rajasthan. A total relief of Rs. 25,277 crore has been disbursed so far by the central government to these states under the National/ State Disaster Relief Fund and other schemes to reduce the severe impacts. The situation may worsen further till the expected good monsoons reach these regions.

At the core of this perennial problem occurring with varying magnitudes each year is an age-old cycle of human need and activity- the deficit between demands and supply of the water resources- particularly the need for irrigation to produce more food. This cycle is now overwhelming fresh water resources in critical areas. Economic and agricultural growth models which we have developed over the years are deeply dependent upon the intensive use of water resources. As such our region of the highest agricultural growth which also produces surplus food to maintain the food security for other regions is also the 'global hotspot' of excessive groundwater over-exploitation. This region is largely located in the northwest India comprising the states of Punjab, Haryana, western Uttar Pradesh, Delhi and

Rajasthan. Beneath this region of high agricultural productivity and economic activity groundwater has been continuously disappearing. The fresh groundwater is being pumped and consumed by human activities - primarily to irrigate cropland which account for 95 per cent of groundwater use- faster than the aquifers can be replenished by natural process. The studies by NASA's GRACE satellite and data from the Indian Ministry of Water Resources have clearly shown that groundwater levels have been continuously declining by an average of 1 m every three years (one foot every year). More than 109 km3 of groundwater disappeared between 2002 and 2008 and the trend has further intensified. Current rates of water extraction and application and the dependent food production systems are unsustainable and the signs of an approaching disaster are already visible. If measures are not taken to ensure sustainable groundwater usage, consequences for 114 million residents of the region may include a collapse of agricultural output and severe shortage of potable water.



Fig.1. High water requiring paddy is intensively cultivated in water-deficit northwest region leading to continuous decline of water tables.

Other regions of severe water stress include the Marathwada region of Maharashtra, Bundelkhand, Telengana, and parts of Gujarat, Andhra Pradesh and Karnataka. All these sub-regions are part of the Deccan plateau and have an unfavourable hydro-geological regime. Agriculture and rural livelihoods in these

regions are largely rain dependent and are highly vulnerable. In the hardest hit region of Maharashtra three-quarters of the farmland is un-irrigated and rain-fed, 79 % of its farmers are small and marginal and eke out a living from tiny parcels of land. At the same time, rest of the Maharashtra grows water-intensive crops like sugarcane, banana and cotton albeit with very low and uneconomical yield levels. Maharashtra along with all the other districts in this water stressed region require very deep thought and changes. The cropping patterns and the state water and energy policies need to be synchronised with the existing water, soil, climatic conditions and the production potentials.

The potential options for a sustainable solution to the prevailing drought conditions and alleviation of the future water and agriculture distresses may include the following:

i. **Decouple agriculture and economic growth from water use and water pollution**: Due to inefficiencies in water supply and consumption systems the existing growth models, growth centres and the even the growth sectors in the developing countries including India are highly water-centric and water intensive. Small deviations in water supplies manifest in large distress signals. Rate of water resource use is still increasing at a rate faster than that of economic growth and by 2030, there will be a 40% gap between water supply and demand if current trends in water development and management continue. Sustainable investments in improved technologies and innovations for improved efficiency and water productivity at the appropriate scale are imperative for decoupling water use from economic growth.



Fig. 2. Innovation in solar energy and precision agriculture in poly houses have the potential of transforming millions of poor rural lives in India.

ii. Water harvesting for water security: On a macro-scale India is sufficient in water resources but the main problem arises due to its highly skewed temporal and spatial variations. Water is available in abundance in seasons (monsoon) and regions (east and northeast, hills and coastal regions and elsewhere) when the demands are low and the capacity to store it on the surface and underground is limited. The Centre, state and the Panchayats must build more dams and storage structures; big, small and tiny to store a much larger share of the available rains, once it has satisfied the environmental needs. For example Vidarbha gets more rain than the drier parts of Gujarat, but has developed much less water harvesting infrastructure as Gujarat has, and so suffers much larger.

iii. Integrated water resources management: India needs a policy for national, integrated use of water across the country and across all the sectors, based on equitable entitlements for all the Indians. Water maybe allocated on priority and on sustainable basis to the sector, stakeholder, city/municipality and village panchayat which exhibit good 'technical efficiency'-the allocated resource is used most efficiently- ; and 'allocative efficiency'- each cubic metre of water produces high comparative value from the resource, 'more crop or value per drop of water'. This should also ensure that the user does not pollute or contaminate the resource beyond the permissible limits and should put in place machinery and mechanisms for safe discharge of the used resources.

iv. Innovations in improving technical efficiency: In spite of the water shortages, the resource is still conveyed and consumed in the most inefficient manner leading to high conveyance and application losses leading to under-served or deprived stakeholders and degradation of the resource. Smarter materials and designs of canals and pipelines should be planned to make equitable and efficient access of water a reality. To the extent possible and especially in critical areas water may be conveyed through underground pipeline systems and farmers encouraged to use plastic conveyance pipes for irrigating the check-basins and furrows. Additionally, such systems will enhance the input use efficiency of the applied fertilisers and nutrients and improve crop and produce quality.



Fig.3. Plastic pipes help in safe and secure water pump age and transportation of the limited water resources.

v. **Modern methods of need-based water application**: Plants and crops grow very well when their root zones remained properly watered so that the nutrients can move upwards and plant temperatures remain stable. Any additional applications of water are sheer wastage and also escalate the costs of other inputs. The precision application of water through micro-irrigation methods like drip irrigation, micro-sprinklers and overhead sprinklers are the most appropriate methods to apply right amount of water at the right time and at the right location. Benefits of the micro-irrigation methods are well documented and appreciated all over the world and by thousands of progressive farmers in India. This should be promoted and adopted under all suitable conditions and the few bottlenecks for its quick adoption may be addressed as below:

a. The initial high cost of capital investment for a suitable water source (tubewell/ pump) and the micro-irrigation equipment may be partially met through subsidies for the deserving categories of farmers and/ or bank credit at affordable interest rates. The procedure for securing such assistance should be simple with minimal documentation, quick and time-bound with transparent pricing and high quality.

b. Most farmers need initial training and capacity building for installation, operation and maintenance of the irrigation equipment. Ideally such programs may be organised at the location or in the same village and all doubts/ queries may be addressed. Enough stocks of spare parts and consumables may be available at short notices and in the rural vicinity.

c. Good forward and backward linkages may be established to remove any bottlenecks in the production cycle from supply of inputs and services, addressing any difficulties during the season and purchase of the produce at appropriate prices so as to cover for all the costs and sufficient margins.

vi. **Synchronising the production centres with the agro-hydrology of the region**: An important factor for the prevailing water stress and production under unsustainable conditions is that our main production centres of the major crops and commodities are located in the region which are not hydrologically suitable for the current cropping system. It may not be possible to completely alter the cropping systems but provision of suitable alternatives atleast in the critical areas may be able to alleviate the problem and the production systems more aligned with the local agro-hydrology. Some of the possible suggestions are:

a. Northwest region of India receives much less rainfall (around 550 mm), has high temperatures and evaporative demands during summers but still extensively cultivates paddy on porous soils with very high water demands. It has got a well-developed irrigation infrastructure, agricultural markets and rural roads and farmers also enjoy free or highly subsidised power for groundwater pumping- a perfect recipe for depletion and over-exploitation. It is estimated that a minimum of 10-15% of the paddy lands in the critical areas need to change their farming systems to include more of fodder production and dairying, vegetables and fruits of high cash value, and pulses and oilseeds. Any perceived shortfall in grain production can be possibly met through the suggested program of 'Bringing Second Green Revolution in the Eastern India'.



Fig. 4. Simple plastic sheet based small polyhouses help in water conservation and high value crop production under diverse climatic conditions.

b. Maharashtra has limited rainfall and an inadequate irrigation infrastructure. Several of its regions perennially witness water shortages, water distress, and largescale outmigration of humans and cattle. Surprisingly, Maharashtra is also one of the largest cultivator of the water-guzzling sugarcane and cotton crops limited to specific pockets. Water consumed by one hectare of sugarcane or cotton crop can easily support 3 or 4 hectare of alternate crops of pulses and oilseeds, vegetables and horticulture, dairy farming; chillies, onions and spices; all of which are quite suitable and remunerative in the region. A part of the sugarcane and cotton region need to be replaced with the suggested cropping systems and production moved to other location which are more suitable for the crops.

vi. Innovations in the use of Plastics in the Next-Generation Water-Secure Agriculture

Water security means adequate quantities of water of an acceptable quality are available at the required time and at the required place or in its vicinity and at an affordable cost for the user whether he proposes to use it for consumptive purposes (domestic needs) or productive purposes (agriculture, industry,

livelihoods, health and sanitation, environment and aesthetics). Since bulk of water in India is available during a limited season and its availability is regionally differentiated, the best possible option is to store it, convey and transport it and finally use it with the utmost efficiency. Plastics are a wonderful material which can meet all the above stated needs at a very affordable cost and help to use the precious water resource efficiently, productively and sustainably. The following suggestions need consideration and wide scale adoption:

i. *Water storage*: All medium, micro and tiny water storage structures may be suitably designed and lined with plastic sheets and or stored in suitable plastic structures to reduce leakages and wastages. Low density polyethylene lined farm reservoirs/ tanks, jalkunds, cisterns, jars offer great opportunity for long term safe storage of the resource under most climatic conditions. Under harsher conditions, such structures may be made underground (tankas) or suitably covered/ thatched with mulches to check high evaporative losses.

ii. *Water conveyance and transportation*: In arid, semi-arid, desert, coastal, hilly and other areas of freshwater scarcity, the conveyance and transportation of water through suitable plastic pipes is highly convenient and desirable. In areas of Rajasthan, Haryana, Gujarat and several other states plastic conveyance pipes of length upto 1 km can be seen during the irrigation season. Besides reducing the conveyance losses, these are ideal mechanisms for development of groundwater markets, cooperative sharing of the water resources, tide over the problem of irrigating tiny scattered holdings, and overcome poor water quality issues. But most of such interventions are taking place without the active public and private support, lack of design of innovative products and services and capacity building of the users. A thoughtful policy and required actions can kick start and invigorate the water conveyance and transportation sector.

iii. *Water application and consumption*: This component of the agricultural water management system has received some attention through suitable designs, manufacturing and services of the micro-irrigation systems in the form of drips, micro-sprinklers and sprinklers. There has always been a high emphasis on the adoption and popularisation of these systems and a number of committees and projects have made useful recommendations. The twin objectives of the most recent program of “Pradhan Mantri Krishi Sinchayee Yojanana” of 'providing water to each farm' and 'more crop per drop' can be realised only with



Fig.5. Micro-irrigation industry helps to convert water-intensive low-value agriculture to a high-value diversified agriculture. (Photo credit: IWMI)

with an active support and vision from the plastic based irrigation industry. In spite of all the past and present emphasis, the actual need felt by the farmers and planners and potential of this industry, the gains and spread of this sector has been small and largely driven by the state and central subsidies and supports. The need is to come out of this model of growth and develop the products and services which are affordable to all the interested farmers. The economic parameters of B:C ratios, IRRs and the pay-back periods may be greatly improved in such a manner that farmers find it highly attractive and the adoption of micro-irrigation becomes a self-driven mass movement. This shall be a win-win situation for the plastic industry, ushering in of the next generation agriculture and conversion of water-stressed-agriculture to water-secure productive agriculture.

16. Per Drop More Crop: It's now or Never

By Mr. Puneet Singh Thind
Director,
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We never know the worth of water; till the well is dry. Nature reminds us once again how precious Water is for our lives; as evident from recent pictures of Latur and other parts of India. Drying ponds, dying animals/birds, failing crops, regular droughts; all these are the alarming indicators for human life. Likewise, in farming the challenge of Irrigation Water is a critical input too. How much, at what time and how plants are watered has determining effect on the eventual yield. Good seeds and fertilizer fail to achieve their full potential if plants are not optimally watered. Adequate availability of water is important for animal husbandry as well. Fisheries are, of course, directly dependent on water resources.

Increasing incomes, growing urbanization and rising prosperity are rapidly changing the composition of food basket away from cereals towards high value agricultural commodities such as fruits, vegetables, milk, poultry, fish and meat. Although per capita consumption of food grains has declined over the years, its total demand has been projected to increase due to increase in population and indirect demand from feed. Most of the fruits, vegetables and livestock products are more water intensive as compared to cereals other than rice.

Further preference to have fresh fruits and vegetables in all the seasons is resulting in increase in their cultivation in off season requiring much higher use of water. The amount of water required to produce a unit of animal origin products (chicken, mutton and eggs) is much higher than plant origin products (cereals, pulses and oilseeds).

India accounts for about 17 per cent of the world's population but only 4 per cent of the world fresh water resources. Distribution of these water resources across the vast expanse of the country is also uneven. At present, irrigation consumes about 84 per cent of total available water. Industrial and domestic sectors consume about 12 and 4 per cent of total available water, respectively. With irrigation predicted to remain the dominant user of water, "per drop more crop" is an imperative.

The efficiency of water use lies majorly on two fronts i.e. expanding the area under irrigation with the same available water and conserving the water through efficient

practices. Irrigation infrastructure in India has seen substantial expansion over the years. The total irrigation potential created (IPC) from major, medium and minor irrigation schemes has increased from 22.6 million hectares during pre-plan period to 113 million hectares at the end of the 11th Plan. Because this irrigation potential represents 81% of India's ultimate irrigation potential estimated at 140 million hectares, the scope for further expansion of irrigation infrastructure on a large scale is limited. Therefore, priority must be given to improving the utilization of irrigation potential of the existing irrigation potential. Over the years, there has been significant shift in the sources of irrigation. The share of canal in net irrigated area has declined from 39.8 % in 1950-51 to 23.6 % in 2012-13. Alongside, the share of groundwater sources has increased from 28.7 % to a whopping 62.4 % during the same period. This expansion reflects the reliability and higher irrigation efficiency of 70-80% in groundwater irrigation compared with 25-45% in canal irrigation.

While proving to be a valuable source of irrigation expansion, injudicious utilization of groundwater through the explosion of tube wells has raised several sustainability issues. Although overall development of groundwater (groundwater draft as a proportion of the total availability) is 62 per cent, there exists wide regional variability. Over-dependence on groundwater beyond sustainable level use has resulted into significant decline in the groundwater table, especially in northwest India. The Central Groundwater Board has categorised 16.2 per cent of the total assessment units-Blocks, Mandals or Talukas-numbering 6607 as 'Over-exploited'.

It's vital that Agriculture has to move from traditional crop centric farming to agri-pastoral-farm forestry systems (fruit trees, shrubs, perennial grasses and small ruminants). Cross-country comparison of water use efficiency shows that India uses 2-3 times the water used to produce one tonne of grain in countries like China, Brazil and USA. This implies that with water use efficiency of those countries India can at least double irrigation coverage or save 50 per cent water currently used in irrigation. Achieving these gains would require the application of multiplicity of instruments.

These may include: 2 Moisture index = [{actual rainfall (P0)-potential evapotranspiration (PET)}/ PET]*100. PET is the water requirement to meet the evaporation and transpiration needs of a large area completely and uniformly covered with growing vegetation having access to an unlimited supply of soil water and without advection or heating effects.

- The method of irrigation followed in the country is flood irrigation, which results in a lot of water loss. Greater efficiency in irrigation can be achieved through proper designing of irrigation system for reducing water conveyance

loss. Adoption of water saving technologies such as sprinkler and drip irrigation system have proven extremely effective in not just water conservation but also leading to higher yields by delivering water in a controlled manner in parts of the plant where it is most efficiently absorbed. New agronomic practices like raised bed planting, ridge-furrow method of sowing, sub-surface irrigation, precision farming offers vast scope for economising water use.

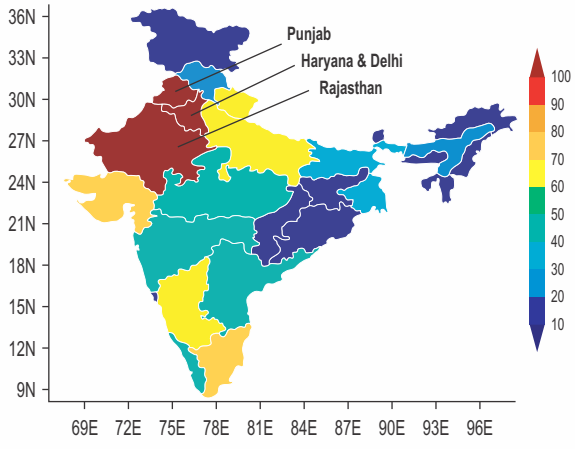
- Promotion of alternative methods of planting such as System of Rice Intensification and Direct Seeded Rice can lead to water saving and productivity increases.
- Water productivity can be improved by adopting the concept of multiple use of water, which is beyond the conventional sectoral barriers of the productive sectors. There is scope for increasing the income through crop diversification and integration of fish, poultry and other enterprises in the farming system. Multiple use of water approach generates more income benefits, decreases vulnerability by allowing more diversified livelihood strategies and increases sustainability of ecosystem.
- Emphasis should be given on water resources conservations through watershed development in suitable areas and development of micro-water structures for rainwater harvesting. The promotion of water conservation efforts has direct implications for water resources availability, groundwater recharge and socio-economic conditions of the population.
- Specialised solution is required in chronically water stressed areas where the normal measures may not be effective. Connecting highly water stressed areas with perennial source of water through linking of rivers or water grids is one such option. The value added agri-horti-pastoral agro-forestry systems and alternative source of livelihood are required in these districts. These districts could be ideal candidates for prioritised intervention of watershed plus activities (water conservation along with livelihood support activities) under recently launched Pradhan Mantri Krishi Sinchai Yojana (PMKSY) and convergence with MGNREGA.
- Farmer Organisations, Farmer Producer Organisations, Village Level Cooperatives, Village Panchyat, NGOs and civic bodies will have to play an important role in educating farmers to adopt these water saving practices while not to take the things for granted anymore.

17. A Window to Plasticulture

By Mr. P S Singh
Head,
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1. Right usage of water is becoming increasingly important given the fact that India currently supports nearly 17.84% of the world population, with 2.4% land and 4 % of water resources. At the same time, monsoons are also becoming erratic. The resultant is alarming fall in ground water levels. At present, irrigation consumes about 84 per cent of total available water As per Economic survey of India February 2016, although water is one of India's most scarce natural resources, India uses 2 to 4 times more water to produce a unit of major food crop then does China and Brazil.

2. As per International Water Management Institute, during the past decade, groundwater in various parts of the country, esp. beneath the northern Indian states of Punjab, Haryana & western UP has fallen at an alarming level. This will impact the food security of the nation as the region also happens to be its food bowl. The given map shows the groundwater withdrawals as a percentage of groundwater recharge.



(Credit: NASA/Matt Rodell, Source –International Water Management Institute)

3. The resultant is alarming fall in ground water levels placing at risk, the national food security mission. It is imperative that the country gives focus to efficient usage of water in Agriculture. As per World Resources Institute, 54 % of India faces high to extremely high Water stress.

4. Plasticulture - Need of the Hour

Plasticulture viz: the use of plastics in agriculture, horticulture, water management and related areas provides an answer to the problem. The usages of plastics not only maximize the output of farms but also optimize the input factors thereby leading to high productivity of crops along with efficiencies in time and cost involved. It is estimated through appropriate adoption of micro-irrigation technologies can result in water saving up to around 50-70-%. Consumption of fertiliser is also reduced through fertigation. The resulting improvement in net farm incomes is substantial. The table below provides benefits of plasticulture applications.

S.No.	Plasticulture Applications	Water Saving (%)	Water Use Efficiency (%)	Fertilizer Use Efficiency (%)
1	Drip Irrigation System	40-70	30-70	20-40
2	Sprinkle Irrigation System	30-50	35-60	30-40
3	Plastic Mulching	40-60	15-20	20-25
4	Greenhouse	60-85	20-25	30-35
5	Shade nets	30-40	30-50	Under Trial
6	Plastic Tunnel	40-50	20-30	-do-
7	Farm Pond Lined with Plastic Film	100	40-60	Not Applicable

Source: *NCPAH*

1. The growing use of plastics in different segments of economy has been very useful. The use of plastics esp. in agriculture has helped farmers increase crop production, improve food quality as also in more efficient usage of water resources.

2. In order to meet the food grain requirements of the nation, the agricultural productivity and its growth needs to be sustained and further improved. Given the limitation of the important input, viz: water, Plasticulture can play a very important role in same.

3. Plasticulture (viz: the use of plastics in agriculture, horticulture, water-management, food grains storage and related areas) is a good answer to this challenge of water shortage. It can play an important role in facilitating judicious usage of water. It is estimated that appropriate applications of micro-irrigation technologies can result in water saving upto 50-70-%. At the same time, consumption of fertilizers is also reduced thru Fertigation. Plasticulture

applications offer a multitude of benefits and are considered most important indirect agricultural inputs which results in moisture conservation, water saving, reduction in fertilizer consumption. It also helps in precise application of water & nutrients, and use of innovative packaging solutions help in increasing shelf-life and during collection, storage & transportation of fruits and vegetables.

4. A promising way forward, to increase productivity while conserving water (more for less), is to adopt micro irrigation methods. In drip irrigation for example, perforated pipes are placed either above or slightly below ground and drip water on the roots and stems of plants, directing water more precisely to crops that need it. An efficient drip irrigation system reduces consumption of fertiliser (through fertigation8) and water of the plant and hence there is less wastage. Yields of crops also went up - up to 45 per cent in wheat, 20 per cent in gram and 40 per cent in soybean. The resulting improvement in net farm incomes is substantial. Until now micro-irrigation techniques, owing to high fixed costs of adoption, have mostly been used for high value crops. However, recent research has shown its feasibility even in wheat and rice.

5. Due to their versatility, and imperviousness to water, Plastics save significant amounts of energy and water resources and emit lower quantum of green house gases. They have already displaced many traditional materials, such as wood, leather, paper, metal, glass and ceramic, in most of their former uses.

   - **Plasticulture applications** are one of the most useful indirect economy & agriculture inputs with huge unrealized potential such as:
   - **Water Management**-Lining of canals, ponds & reservoirs with plastics film/Drip & sprinkler irrigation system/Water conveyance using PVC & HDPE pipes & Sub-surface drainage
   - **Nursery Management**-Nursery bags, Pots, Pro-trays, Root trainers, Coco peats, Hanging baskets, Plastic trays, etc.
   - **Surface cover cultivation** -Soil Solarisation /Plastics Mulching
   - **Controlled environment agriculture**-Greenhouses/Shade net houses/Plastic tunnels/Plant protection nets
   - Innovative Packaging Solutions-Plastic crates, bins, boxes, leno bags, unit packaging nets etc/CAP covers, controlled atmospheric packaging (CAP) & modified atmospheric packaging (MAP)
   - Organic Farming-HDPE vermin bed

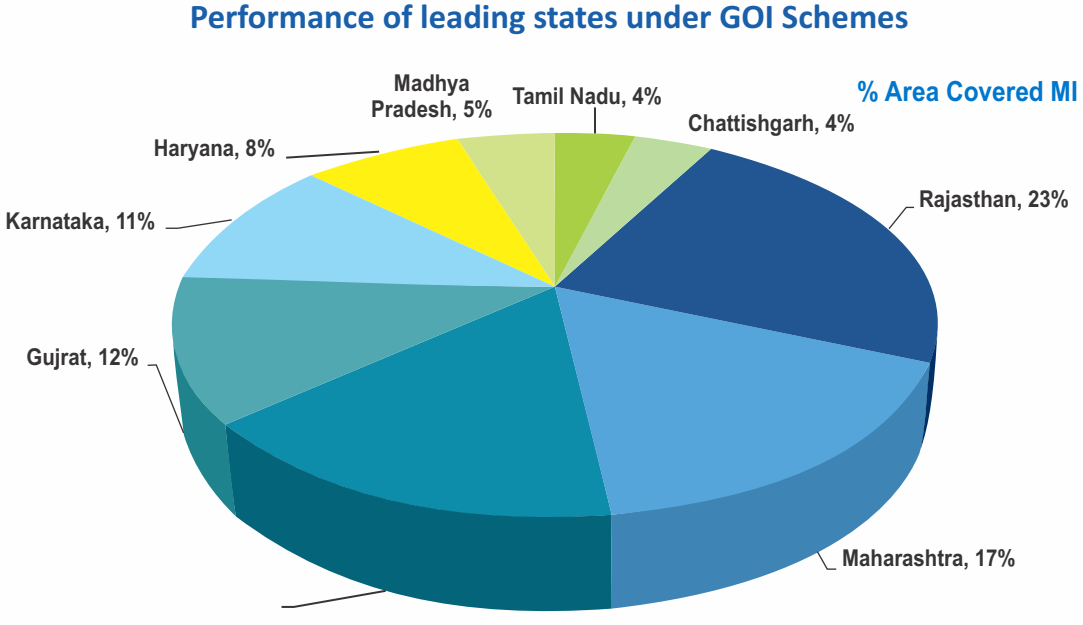
6. **Benefits of Plasticulture Applications-**

   Same can help the country to meet both food and nutrition needs at a time when population growth is @ +1% per annum with depleting natural resources such as land & water.

7. While the usage and benefits of plastics are manifold, the sector has an image issue (which can be linked to inappropriate civic handling of waste). The myth regarding the polluting characteristic of plastic needs to be addressed in a very scientific manner. If plastics can be collected and disposed off or recycled as per laid down guidelines/rules, the issue of plastic waste can be suitably addressed. In fact, there is good potential for industries based on re-cycling of plastics waste.

8. However, the quantum of usage of plasticulture applications is still limited in India. Out of total 126 million hectares (mha) of area under cultivation in the country, an area of 69.6 million hectares holds potential for micro-irrigation. At present only about 7.5 million hectares is covered by micro-irrigation. This indicates huge gap/potential for micro-irrigation in the country.

9. In a recent survey conducted on the GoI scheme for National Mission on Micro Irrigation (NMMI), it is highlighted that scheme has performed well in terms of reduction in input cost to the tune of 20% - 50% along with energy savings. Approximately 7.4 mha have been covered under GoI scheme.



Performance of Leading states under GOI Schemes

10. Incidentally the enhanced application of plasticulture concept will also create opportunities for the Indian plastic industry. Plastics such as PVC, LDPE, LLDPE, HDPE, PP, PTFEE etc find good applications in the sector. As we are aware, there is a huge unrealised potential of further growth of plastic industry as indicated by the present very low per capita consumption level in the country. The same is only about 10 kgs in india compared to world average of 28kgs and about 109 kgs in USA .

11. Concluding, it can be stated that the plasticulture applications hold huge importance because of their relationship to water conservation and national food security. A very focused campaign to create awareness about its usage (thru demonstration centres) in which farmers are partners will be helpful. At the same time, there is need to ensure availability of quality products based on good standards by industry. There is also need for bringing out literature on the subject in regional languages, which may also include case studies. These steps will go a very long way in promoting the idea of plasticulture in India.

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Founded in 1991 as a division of Tata Industries Ltd, Tata Strategic Management Group is the largest Indian own management consulting firm. It has a 50 member strong consulting team supported by a panel of domain experts. Tata Strategic has undertaken 1000+ engagements, with over 300 clients, across countries and sectors.

It has a growing client base outside India with increasing presence outside the Tata Group. A majority of revenues now come from outside the group and more than 20% revenues from clients outside India.

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• Revenue	• Cost	• Profit
• Market Share	• Throughput	• Lead Time
	• Key Milestones	• Uptime

*Illustrative

Knowledge and Strategy Partner

TATA STRATEGIC MANAGEMENT GROUP

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About FICCI (Federation of Indian Chamber of Commerce and Industry)

Established in 1927, FICCI is the largest and oldest apex business organisation in India. Its history is closely interwoven with India's struggle for independence, its industrialization, and its emergence as one of the most rapidly growing global economies.

A non-government, not-for-profit organisation, FICCI is the voice of India's business and industry. From influencing policy to encouraging debate, engaging with policy makers and civil society, FICCI articulates the views and concerns of industry. It serves its members from the Indian private and public corporate sectors and multinational companies, drawing its strength from diverse regional chambers of commerce and industry across states, reaching out to over 2,50,000 companies.

FICCI provides a platform for networking and consensus building within and across sectors and is the first port of call for Indian industry, policy makers and the international business community.

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Industry's Voice for Policy Change