Knowledge Paper on

Plastics Industry

National Conference on
Potential of Plastics Industry in
Northern India
WITH FOCUS TO PLASTICULTURE
(Micro Irrigation and Post-Harvest Management)
June, 2015 at Chandigarh

Knowledge and Strategy Partner

TATA STRATEGIC MANAGEMENT GROUP
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During the past decade, groundwater beneath the northern Indian states of Punjab and Haryana, has decreased at an alarming rate. That will impact the food security of the nation as the region also happens to be its food bowl. Plasticulture (viz: applications of plastics in agriculture) is an answer to this challenge. Full potential of applications of plastics in agriculture and food processing is yet to be tapped. It is estimated that appropriate application of micro-irrigation technologies can result in water saving of upto 60-70%.

This incidentally also creates an opportunity for Indian Plastics Industry. To bring a focus to plasticulture, FICCI jointly with Department of Agriculture & Cooperation & Department of Chemicals & Petrochemicals, Govt. of India, is organizing the National Conference on "Potential of Plastics Industry in Northern India with focus to Plasticulture. This indeed is a timely initiative and I wish it all success.
India currently supports nearly 17.50% of world’s population with 2.4% land resources and 4% of water resources. The Indian Agriculture sector is consuming almost 80% of available water. As per International Water Management Institute, during the past decade, groundwater especially beneath some northern Indian states has fallen at an alarming level. This may impact the food security of the nation as the region also happens to be its food bowl. Appropriate application of plasticulture can help in meeting the above challenge. FICCI jointly with Department of Agriculture & Cooperation & Department of Chemicals & Petrochemicals, Govt. of India, is organizing a National Conference at Chandigarh which will bring focus to the issue as also possible solution. I wish this initiative all the best.

PRABH DAS
Chairman-FICCI National Petrochemicals Committee
Managing Director & CEO
HPCL-Mittal Energy Limited
India currently supports nearly 17.50% of world’s population with 2.4% land resources and 4% of water resources. The Indian Agriculture sector is consuming almost 80% of available water. As per International Water Management Institute, during the past decade, groundwater especially beneath some northern Indian states has fallen at an alarming level. This may impact the food security of the nation as the region also happens to be its food bowl.

Appropriate application of plasticulture can help in meeting the above challenge. FICCI jointly with Department of Agriculture & Cooperation & Department of Chemicals & Petrochemicals, Govt. of India, is organizing a National Conference at Chandigarh which will bring focus to the issue as also possible solution. I wish this initiative all the best.

PRABH DAS
Chairman-FICCI National Petrochemicals Committee
Managing Director & CEO
HPCL-Mittal Energy Limited
Federation of Indian Chambers of Commerce & Industry (FICCI) & TATA Strategic Management Group (TSMG) have been regularly tracking plastics & petrochemicals industry. TSMG has been supporting companies, both big and small, across the industry value chains to achieve business excellence. The same knowledge and experience gives us an additional advantage to realize this report.

Accelerated globalization, rapid change in technology and growing consumerism have brought with it sweeping changes and abundant opportunities for plastic industry to grow domestically and globally. Significant investments are coming up in India in this sector in the next few years. Growth in the petrochemical sector will improve the feedstock availability for the plastic production. For example, Reliance Industries Ltd (RIL) is planning to invest USD 16 billion to expand petrochemical production capacity by FY18. Indian Oil Corp (IOCL) is planning to invest USD 1.3 billion in setting up a petrochemical complex at Paradip refinery in Odisha by FY19. Besides these, four PCPIR’s are under various stages of development which will further improve the petrochemical landscape in India. In September 2014, GOI has announced ‘Make in India’ initiative to catalyze Indian manufacturing. Additionally, GOI is also promoting ‘100 smart cities. It is clear that plastics will be called on to play a vital role in this changing landscape and plastic industry will benefit from national efforts to encourage and improve manufacturing.

Historically, major percentage of the population in northern India has been engaged in agriculture. Though the land is very fertile, the farmers are affected with the problems of low productivity and low return on investment primarily due to heavy dependence on monsoons. Going forward, plasticulture applications have the potential to offer them the much needed solutions to improve productivity and reduce dependence on monsoons and therefore, will drive the demand for plastics.

As per industry estimates, 35-40% of the food products produced in India are wasted due to deficient infrastructure and lack of food processing capabilities. Plastics find applications in packaging which protects the longevity and quality of food. This sector in India also offers significant potential for growth leading to increase in demand for plastics. Beyond this due to various benefits like increase in the yield, reducing water losses, cleaner produce due to reduced soil contact etc. plasticulture farming has evolved significantly in the recent years.

We sincerely thank all participants whose valuable inputs have helped in developing this report. As always, it was an insightful experience for the team to materialize this report.
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Knowledge Paper on Plastics Industry

I. Executive summary

Plastic industry is making significant contribution to the economic development and growth of various key sectors in the country such as: Automotive, Construction, Electronics, Healthcare, Textiles, FMCG, etc. It has expanded at 11% CAGR over the last five years to reach 12.2 MnTPA in FY14. However, India observes significant regional diversity in consumption of plastics with Western India accounting for 45%, Northern India for 24% and Southern India for 21%. Bulk of the consumption in Northern India is again from the end use industries such as Auto, packaging (including bulk packaging), plasticulture applications, electronic appliances etc. which are concentrated mostly in UP and Delhi-NCR (>50%). However, plastic processing in other parts like Rajasthan, Punjab, Haryana, Uttarakhand, J&K and Himachal Pradesh are expected to grow in the coming years, based on increased availability of feedstock and higher focus on manufacturing sectors.

Northern India is said to have an inherent disadvantage of being away from ports hence a difficult target for low cost supply of plastics through import. However, this same situation makes the domestic plastic processing more competitive and provides significant opportunity. Current low levels of per capita consumption (~10 Kg) along with increased growth in end use industries could propel the growth of plastics in North India further.

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I. Executive summary

Plastic industry is making significant contributions to the economic development and growth of various key sectors in the country such as: Automotive, Construction, Electronics, Healthcare, Textiles, FMCG, etc. It has expanded at 11% CAGR over the last five years to reach 12.2 MnTPA in FY14. However, India observes significant regional diversity in consumption of plastics with Western India accounting for 45%, Northern India for 24% and Southern India for 21%. Bulk of the consumption in Northern India is again from the end use industries such as Auto, packaging (including bulk packaging), plasticulture applications, electronic appliances etc. which are concentrated mostly in UP and Delhi-NCR (>50%). However, plastic processing in other parts like Rajasthan, Punjab, Haryana, Uttarakhand, J&K and Himachal Pradesh are expected to grow in the coming years, based on increased availability of feedstock and higher focus on manufacturing sectors.

Northern India is said to have an inherent disadvantage of being away from ports hence a difficult target for low cost supply of plastics through import. However, this same situation makes the domestic plastic processing more competitive and provides significant opportunity. Current low levels of per capita consumption (~10 Kg) along with increased growth in end use industries could propel the growth of plastics in North India further.
Looking at the Indian demand, Polyethylene is seen to be majorly consumed thermoplastic, with a demand of 3.6 MnTPA in FY14. But the production of PE in India is still low i.e. 2.9 MnTPA. Therefore, currently India is the net importer of Polyethylene (PE), however with the recent commissioning of IOCL plant at Panipat, the imports are expected to reduce significantly. Besides this, due to the presence and future growth of some the major players like Reliance Industries Ltd (RIL), Gas Authority of India (GAIL), Haldia Petrochemicals.

The plastic industry can reach the apex in the coming years due to its numerous applications in agriculture. In India, 70% of the rural population is dependent on agriculture as their principal mean of livelihood and the polymer utilization by application in agriculture is only 2% compared to the global average of 8%. If plasticulture is efficiently introduced into this segment it can transform the Indian agriculture scenario and bring in the "Second Green Revolution". Plasticulture possess a great potential to increase the production and productivity in various phases of agriculture like during the micro irrigation, water management and post-harvest management practices. It can also bring significant growth in the food processing & packaging industry and can reduce the post-harvest losses.

But at the same time Indian Plastic industry continues to face environmental myths and lacks in advanced technology availability. Going ahead recycling & reuse of plastics could be a foremost step towards fostering innovation and sustainability. Also increased awareness through help of industry groups and Government could help address some of these challenges.

Note: 1. The demand mentioned is of Total Polymers comprising Thermoplastics and Thermosets. However, in this reports the focus is upon the major polymers (PE, PP, PVC, PS& others (EPS& PVC compound)
II. Introduction

The chemical industry is critical for the economic development of any country. Indian chemical sector accounts for 13% of the gross value added by the industries segment. With Asia's increasing contribution to the global chemical industry, India emerges as one of the focus destinations for chemical companies worldwide. Chemical industry is critical for the economic development of any country as it offers products and solutions for virtually all sectors of economy.

The chemical industry in India accounted for USD 118 Bn in FY13 and is expected to grow at 8% p.a. over the next 5 years. Indian petrochemical industry which includes the end products like polymers, synthetic fibers, surfactants, etc. has grown at 11% from USD 19.3 billion in FY11 to USD 27 billion in FY14.

Major driver for the consumption of petrochemicals are plastics. Since plastic products permeate the entire spectrum of daily use items and cover almost every sphere of life like clothing, housing, construction, furniture, automobiles, household items, agriculture, horticulture, irrigation, packaging, medical appliances, electronics and electrical etc. Current low per capita consumption level of plastic products in India as compared to
developed countries indicates that India offers a huge opportunity over long term (Refer Figure 1).

![Figure 1: Per capita plastic products consumption (Kg/person)](image)

Source: PlastIndia, Business Press, Research by Tata Strategic

Packaging industry in India has seen a strong penetration of plastics as compared to global standards. However, agriculture sector still hasn’t explored the benefits of plastics to a large extent. Global average for plastics demand in agriculture is 8% while India is substantially lower at only 2%.

![Figure 2: Polymer utilization by application, FY13](image)
Driven by the increased focus on the Make in India campaign, Ministry of Chemicals & Fertilizers and the Central Institute of Plastics Engineering & Technology (CIPET) have actively extend their support for the growth of plastic industry in India. For e.g, an export-oriented plastic cluster has been proposed to be set up at an investment of over Rs 100 crore in Lucknow. India Industries Association (IIA) in collaboration with CIPET will set up this cluster. Cluster has already generated interest amongst 200 industrialists and entrepreneurs and is expected to generate direct employment opportunity for ~2,500 youth.

Additionally, rising thrust on 100 smart cities will further propel the growth of plastic industry. Considering the critical elements of any smart cities such as water management, infrastructure, waste management, etc. the usage of plastics can bring efficiency in all such fields and can therefore, make the smart cities more sustainable and cost effective.

New investments are expected in plastic sector with 40,800 additional plastic processing machines are expected to be installed by FY15 and could potentially generate 3 million additional employment opportunities. Significant investments planned in sectors such as water & sanitation management, irrigation, power, transport etc. will result in making India a hub for PVC and CPVC product manufacturing.
III. Plastic industry in India

A wide variety of plastics raw materials are produced to meet the material needs of different sectors of the economy. These polymeric materials are broadly categorized as commodity, engineering and specialty plastics. Commodity plastics are the major products that account for bulk of the plastics and in turn for petrochemical industry. And therefore the report mainly emphasizes on the commodity plastics which comprise of Polyethylene (PE), Polypropylene (PP), Polyvinyl Chloride (PVC) and Polystyrene (PS). While engineering and specialty plastics are plastics that exhibit superior mechanical and thermal properties in a wide range of conditions over and above more commonly used commodity plastics and are used for specific purpose. These include styrene derivatives (PS/EPS & SAN/ABS), polycarbonate, poly methyl methacrylate, polycarbonates, poly oxy methane (POM) plastics etc.

There are three broad types of PE, viz: Low-density Polyethylene (LDPE), High-density Polyethylene (HDPE) and Linear Low-density Polyethylene (LLDPE). Major plastic materials like PE and PP are derived from Ethylene and Propylene respectively, while other plastics such as PVC, PS & ABS and PC are produced from benzene, butadiene and other feedstock.
1) Demand overview

Plastics industry is one of the fastest growing industries in India. Compared to the overall plastic industry which is growing at 11%, the major thermoplastics like PE, PP, PVC, PS have grown at 8% per annum over the last five years to reach 8.7 MnTPA (million tonnes per annum) in FY14 from 6 MnTPA in FY09. (Refer Figure 3).

Figure 3: Demand growth of plastics ('000 TPA), CAGR, FY09-14

Polyethylene (PE) is the most largely used plastic raw-material by Indian industry. Its demand has grown at 8% per annum in last 5 years to reach 3.6 MnTPA in FY14. Polyvinyl Chloride (PVC) is the second largest with the consumption growing from 1.4 MnTPA in FY09 to 2.6 MnTPA in FY14 at growth rate of 13% p.a.

Polypropylene (PP) demand has grown at 3% p.a from 1.9 MnTPA in FY09 to 2.2 MnTPA in FY14. Poly-Styrene (PS) has observed a growth rate of 3% p.a. to reach 0.2 MnTPA in FY14, while other (PC/ ABS etc.) have grown at 7% p.a. from 0.09 TPA in FY09 to 0.13 MnTPA in FY14 (Ref figure 4).
Polyethylene (PE), which includes HDPE, LLDPE and LDPE (High Density PE, Low Density PE and Linear Low density PE), accounts for the largest share i.e., 41% of total consumption, while PP accounts for 25% of total consumption. Within PE, HDPE is observing a moderate growth and has a consumption share of 19%. LLDPE is expected to grow at higher pace due to its increased penetration in LLDPE applications. Others include EPS and PVC compounds.

To manufacture finished products, polymers are processed through various types of techniques namely extrusion, injection moulding, blow moulding and roto moulding. Various products manufactured through these processes are highlighted in the following table;

### Table 1: Classification of plastic products by type of process

<table>
<thead>
<tr>
<th>Plastic products</th>
<th>Extrusion</th>
<th>Injection moulding</th>
<th>Blow moulding</th>
<th>Roto moulding</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Films and Sheets, Fibre and Filaments Pipes, Conduits and profiles, Miscellaneous applications</td>
<td>Industrial Injection Moulding, Household Injection Moulding and Thermo-ware/ Moulded luggage</td>
<td>Bottles, containers, Toys and Housewares</td>
<td>Large circular tanks such as water tanks</td>
</tr>
</tbody>
</table>

Source: Chemicals & Petrochemical Statistics, Analysis by Tata Strategic

Source: CIPET

Western region accounts for 45% of the total consumption. The region wise distribution of consumption is given in Figure 5.

Western region comprise of Maharashtra, Gujarat, the union territories of Daman and Diu & Dadra and Nagar Haveli along with Madhya Pradesh and Chhattisgarh.

Northern India accounts for 24%. For the purpose of this report Northern India comprises of J&K, Himachal Pradesh, Punjab, Haryana, Uttarakhand, Rajasthan, UP, Delhi and NCR region.

Bulk of the consumption in Northern India is from the end use industries of Auto, packaging (including bulk packaging), plasticulture applications, electronic appliances etc. Figure below reflects indicative list of some end use industries (Refer Figure 6) in Northern India.
Extrusion process is the most commonly used process in India and accounts for 60% of total consumption by downstream plastic processing industries. Injection moulding is the second most popular process accounting for 25% of the consumption. Blow moulding is used for 6% while Rotomoulding 1%. The rest of the plastic is processed through other processes.

1.1 Region wise break of plastic demand

At present the total consumption of the major plastic (PE, PP, PVC, PS, EPS & PVC Compounds) plastics in India is 8.7 MnTPA. Western India has traditionally been the largest consumer of plastics accounting for almost 45% of the total consumption. The region wise distribution of consumption is given in Figure 5.

**Figure 5: India - Region wise plastic consumption, FY13**

Western region comprise of Maharashtra, Gujarat, the union territories of Daman and Diu & Dadra and Nagar Haveli along with Madhya Pradesh and Chhattisgarh. Northern India accounts for 24%. For the purpose of this report Northern India comprises of J&K, Himachal Pradesh, Punjab, Haryana, Uttarakhand, Rajasthan, UP, Delhi and NCR region.

Bulk of the consumption in Northern India is from the end use industries of Auto, packaging (including bulk packaging), plasticulture applications, electronic appliances etc. Figure below reflects indicative list of some end use industries (Refer Figure 6) in Northern India.
The consumption in Northern India is low as compared to Western India primarily because of lack of availability of raw material. Reliance, the largest petrochemical player in India had all its cracking units in West and this facilitated the growth of downstream plastic processing industry in Western region. However, recent commissioning of IOCL Panipat cracker and HMEL Bhatinda PP plant will facilitate downstream plastic processing units in Northern India.

2) Capacity overview

India has significant production capacity of Plastics. Polyethylene (PE) continues to be the largest commodity with LLDPE experiencing the fastest growth in this category. Current polymer capacities are mostly under-utilized with an operating efficiency varying from 66%-86%, except for PVC, where production matches with capacity (Refer Figure 7).
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India has a 2.9 MnTPA of PE production capacity out of which the combined capacity of LLDPE & HDPE is 2.7 Mn TPA and 0.2 Mn TPA is for LDPE. PP and PVC also have the large production capacities, i.e., 3.1MnTPA and 1.4MnTPA respectively.

India has a 0.57 MnTPA production capacity of PS and EPS. However, all these facilities are based on imported styrene as there is no local production. In case of Engineering Plastics, there is a significant opportunity in India. Currently for ABS, India has a 100,000 TPA production capacity, while PC base resins are all imported. Polyamides have a limited production capacity, while other major engineering plastics are being mostly imported to cater the domestic demand.

Reliance Industries Ltd. (RIL) is the largest producer of commodity plastics in India. It has 1.16 Mn TPA capacity of PE, 2.7 MnTPA capacity of PP and 0.65 Mn TPA capacity of PVC (Refer Table 2). RIL’s production facilities are located in Gujarat and Maharashtra. RIL is the only producer of LDPE in India.

Haldia Petrochemicals Ltd. (HPL) is another key player with PE capacity of 0.71 Mn TPA and PP capacity of 0.39 Mn TPA. HPL’s plants are located in eastern region of India. Other major players are Indian Oil (IOCL) & Gas Authority of India (GAIL) with their plants located at Panipat and Auraiya respectively. These plants mainly cater to the northern regional demand of plastics. IOCL have 0.65 MnTPA production capacities of PE and 0.6 MnTPA of PP.
In downstream plastic processing, there are more than 30,000 processing units across the country, however, mostly small scale. The installed processing capacity in India is 26.5 MnTPA.

2.1 Scenario in Northern India

In Northern India, IOCL, GAIL & HMEL are the three plastic producers with plastic production capacity of 1.25 MnTPA, 0.5MnTPA, and 0.44 MnTPA respectively. Indian Oil Corporation Limited (IOCL) is the largest oil company in India in terms of revenues. It is promoted by the Government of India with Government holding 79% shares. IOCL commissioned its Panipat cracker in February 2011. The Group owns and operates 10 of India’s 20 refineries with a combined refining capacity of 65.7 MnTPA.

Govt. of India has 57% stake in GAIL. It is a dominant player in natural gas trading business and uses natural gas as the feedstock for production of ethylene and in turn produces Polyethylene. GAIL has plans to double its plastic production capacity and is expected to grow the capacity to 0.9 MnTPA by FY16. HMEL’s Bhatinda Polypropylene plant (0.44 MnTPA) was commissioned in 2012. All put together the plastic production capacity is expected to go up to 2.6 MnTPA by FY16.

The figure below maps the plastic production facilities along with their capacities. Availability of 2.2 MnTPA of plastics capacity in Northern region may result in spur of investments in downstream plastic processing. Moreover, since the north region does not have access to ports, hence the import/export potential is restricted because of additional cost of transportation. Additional downstream investment could result in ensuring a self-sufficient demand-supply scenario for the north India.

### Table 2: Production Capacity of plastics by major players, FY14

<table>
<thead>
<tr>
<th>Producer</th>
<th>PE</th>
<th>PP</th>
<th>PVC</th>
<th>Others</th>
</tr>
</thead>
<tbody>
<tr>
<td>RIL</td>
<td>1,165,000</td>
<td>2,700,000</td>
<td>650,000</td>
<td>-</td>
</tr>
<tr>
<td>IOCL</td>
<td>650,000</td>
<td>600,000</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>GAIL</td>
<td>505,000</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>HPL</td>
<td>710,000</td>
<td>390,000</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>HMEL</td>
<td>-</td>
<td>440,000</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Chemplast Sanmar</td>
<td>-</td>
<td>-</td>
<td>250,000</td>
<td>-</td>
</tr>
<tr>
<td>Finolex</td>
<td>-</td>
<td>-</td>
<td>270,000</td>
<td>-</td>
</tr>
<tr>
<td>Supreme</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>272,000</td>
</tr>
<tr>
<td>Ineos ABS</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>60,000</td>
</tr>
</tbody>
</table>

Source: Plastindia, Analysis by Tata Strategic
commissioned in 2012. All put together the plastic production capacity is expected to go up to 2.6 MnTPA by FY16. The figure below maps the plastic production facilities along with their capacities.

Availability of 2.2 MnTPA of plastics capacity in Northern region may result in spur of investments in downstream plastic processing. Moreover, since the north region does not have access to ports, hence the import/ export potential is restricted because of additional cost of transportation. Additional downstream investment could result in ensuring a self-sufficient demand-supply scenario for the north India.

**Figure 8: Plastic production capacities in Northern India**

![Figure 8: Plastic production capacities in Northern India](image)

*Source: Analysis by Tata Strategic*
3) Import-export scenario

India is overall deficit in plastics and a lot of these materials are imported to cater the unmet domestic demand. The major import source countries are Saudi Arabia, Qatar, UAE, Korea, USA, Singapore, Thailand, Germany, Spain and Malaysia. As reflected in Figure 9, India is deficit in PE and PVC. In FY14, 2.4 Mn TPA of PE was produced while domestics consumption was 3.6 Mn TPA. In case of PVC, the FY14 domestic demand stood at 2.5 Mn TPA and the domestic production was 1.3 Mn TPA. Polyamides consumption was 54,000 TPA, while domestic production was 13,000 TPA. Other major engineering plastics were imported.

Few Plastics materials are produced in surplus and these materials are exported to international markets. Major export destinations are China, Egypt, UAE, Turkey, Vietnam, and Indonesia. In FY 14, Indian production of PP stood at 2.6 MnTPA while demand was 2.2 Mn TPA only. Similarly, domestic demand for PS/EPS was 0.3 MnTPA, and production was 0.34 MnTPA.

Figure 9: Demand-supply scenario (’000 MT) of plastics, FY14

![Figure 9: Demand-supply scenario (’000 MT) of plastics, FY14](image)

Source: Chemicals & Petrochemical Statistics, Analysis by Tata Strategic
India is deficit in PE and is dependent on imports for fulfilling demand. In FY14, 1.3 MnT of PE was imported. PP production exceeds the domestic consumption and hence, caters to international markets as well. India exported 0.94 MnT and imported .5 Mn Tof PP in FY14 (Refer Figure 10).

Domestic production of PVC is not enough to cater to the demand and hence 30% of demand is met through imports. 1.2 MnTPA of PVC was imported in FY14. India is a net exporter of PS, while most of the engineering plastics are being imported.

Exports of plastic finished goods have more than doubled from $1.2 Bn in FY07 to $2.7 Bn in FY12. But fierce competition from countries such as China, Indonesia, Taiwan and other South Asian countries are restricting growth. The exports of these value added plastic products could be a huge growth opportunity if Indian manufacturers can increase / maintain their manufacturing competitiveness while ensuring high quality. (Ref: Fig 11 & Fig 12).
1970s witnessed the first Green Revolution in India. With the adoption of high yielding variety of seeds along with better farming techniques like better use of fertilizers, insecticides and pesticides, made it possible for India to turn to a self-reliant agricultural nation. India currently supports nearly 16% of world’s population with 2.4% land resources and 4% water resources. Nearly 70% of the Indian rural population is dependent on agriculture as their principal means of livelihood. However, Agriculture & Allied Sectors (including agriculture, livestock, forestry and fishery) contributes 17.6% of India’s GDP in FY14.

1. Plasticulture Applications
Plasticulture refers to use of plastics in agriculture and horticulture. Plasticulture provides variety of applications in modern agriculture and promise to transform Indian agriculture and bring in the “Second Green Revolution”. Both the quality and the quantity of the crops and other farm products can be optimized using various techniques. Some of the major applications of Plasticulture are:

**Figure 11: Exports of value added plastic products (Bn USD)**

Source: Planning Commission Report

**Figure 12: Product wise breakup of plastic product exports in Fy13**

Source: Plastindia, Analysis by Tata Strategic
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Plasticulture refers to use of plastics in agriculture and horticulture. Plasticulture provides variety of applications in modern agriculture and promise to transform Indian agriculture and bring in the “Second Green Revolution”. Both the quality and the quantity of the crops and other farm products can be optimized using various techniques. Some of the major applications of Plasticulture are:

IV. Plastics applications in Agriculture
2. Plasticulture Potential

India is a vast nation. Every region has got specific agricultural characteristics and problems. These area specific problems can be tackled with 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.

### Table 3: Major Plasticulture Applications

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

Source: Industry Analysis by Tata Strategic

Plastics which are most widely used in agriculture, water management and related applications are PE, (LLDPE, LDPE and HDPE), PP and PVC.(Refer : Table 4)

### Table 4: Polymers used in Plasticulture applications

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

Source: Industry Analysis by Tata Strategic
2. Plasticulture Potential

India is a vast nation. Every region has got specific agricultural characteristics and problems. These area specific problems can be tackled with 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.

Table 5: Region specific agriculture issues

<table>
<thead>
<tr>
<th>States/Parts of States</th>
<th>Region Specific Constraints</th>
</tr>
</thead>
<tbody>
<tr>
<td>J&amp;K, HP, Uttarakhand</td>
<td>Severe soil erosion, Land Degradation, Poor market delivery infrastructure</td>
</tr>
<tr>
<td>Bihar, Eastern UP, West Bengal</td>
<td>Flood/Water logging, improper drainage, salinity, contamination</td>
</tr>
<tr>
<td>Western UP, Punjab, Haryana</td>
<td>Groundwater depletion, micro-nutrient deficiency, decreasing productivity</td>
</tr>
<tr>
<td>Assam, NE States, Sikkim</td>
<td>Aluminum toxicity and soil acidity, soil erosion and floods, shifting agriculture</td>
</tr>
<tr>
<td>Orissa, Jharkhand, Chhattisgarh</td>
<td>Moisture stress, drought, soil acidity, iron toxicity, poor infrastructure.</td>
</tr>
</tbody>
</table>

The application of Plasticulture can substantially decrease the costs and therefore can lead to high productivity with a better quality of crops. Table 5 shows the potential benefits from Plasticulture applications in terms water saving, water use efficiency and fertilizer use efficiency. Each 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 to zero which is highly beneficial. Also efficient use of fertilizers can bring the costs down which again is beneficial for the famers.
3. Opportunity with Plasticulture

To sum up, following are the opportunity that the agriculture sector has with enhanced usage of Plasticulture applications:

- Yield improvement upto 50-60%
- Water savings upto 60-70%
- Prevention of weeds growth
- Soil conservation
- Protection against adverse climatic conditions
- Fertilizer savings upto 30-40%
- Reduction in post-harvest losses
- Conversion - cold desert/wasteland for productive use

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 13). 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 13: Potential growth in Agriculture-GDP (in Rs. Cr.) through Plasticulture, FY13

Greater Utilization of Plastic can drive –
• Food processing industry
• Improve agricultural productivity
• Reduce post harvest losses
Surplus grain production in North India is central to the national food security as it meets the food deficits of several other regions. However, these large positive benefits have also led to significant drop in the water table. Urgent and innovative solutions are necessary to make the model of the green revolution hydrologically sustainable. Plastic based solutions could be utilized to deal with water scarcity.

Handling water scarcity through plastic based solution

1. **Water storage for surplus rainfall** - Polythene lined tanks can be used to collect excess rainfall especially in the states of Jammu & Kashmir, Himachal Pradesh and Uttarakhand. These tanks situated on the terraces supply water under gravity and can be connected to low head drips and micro-sprinklers and do not need any additional energy. Bucket or drum kit based plastic drip systems, cisterns, plastic lined trenches, etc. can also be used to directly harvest the rain water.

2. **Canal commands linkages with plastic lined tanks (Diggis)** - This solution is more relevant in arid states such as Rajasthan where ground water is saline, canal supply is uncertain & erratic and large part of water get wasted due to highly sandy and undulating soils. In such situation water can be stored in plastic lined diggins and apply to the farms as per need through plastic pipes and sprinkler/drip systems.
3. **Plastic based resource recovery and reuse model** - Plastic can be used for the safe disposal and use of wastewater which has become a huge problem after provision of household sanitation in rural areas. Wastewater can be collected in plastic lined tanks and safely used for agriculture after primary treatment.

The plastics based innovative solutions, besides the traditional interventions already well known, could synergise the growth of agriculture and plastics industry and also enhance the incomes and livelihoods of those engaged in the production systems and a better value for the large consumers.

**Micro Irrigation**

Conceptually micro irrigation, refers to low pressure irrigation system that either drips or sprinkles water needed by the plant for its optimum growth. Modern techniques such as drip/sprinkle irrigation can be utilized to conserve water and bring in efficiency in crop production. Government is actively promoting the implementation of micro irrigation technologies by providing financial assistance under the centrally sponsored schemes.

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.

![Figure 14: Performance of leading states under GOI Schemes](image)

Source: FICCI research paper on Plastics in agriculture.
Plastic application in Micro Irrigation

Plastics have found efficient usage in these micro irrigation systems in the form of PVC pipe fittings, LDPE tubes, plastic mulches etc and have proven to be advantageous in many forms such as;

### Table 7: Benefits of Plasticulture in Micro Irrigation

- 1. Soil erosion is eliminated
- 2. Helps to increase yield and reduces soil compaction.
- 3. Suitable for uneven/ undulating land
- 4. Control weed growth and diseases
- 5. Improves quality and ensures early maturity of crops.
- 6. Increase in Production & Productivity

Source: Industry Analysis by Tata Strategic
The most important concern during post-harvest management is to attain maximum shelf life of the produce; for which the fruits and vegetables are to be kept in excellent condition and are supposed to be of excellent quality. However, the best quality of the produce is only at the moment of the harvest. After that, the quality cannot be improved but can be maintained.

Since the shelf life of the commodity begins at harvest, it becomes important to use appropriate methods for sorting, storing, handling, packing, transporting, etc. from the stage of harvest till the time the commodity reaches the end user.

Plastics have been quite effective when it comes to maintaining the quality of the produce or for handling, disposal, storage, packaging etc.
Table 8: Use of Plastic in post-harvest management

<table>
<thead>
<tr>
<th>Applications</th>
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</tr>
</thead>
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| Plastic Sacks        | • Used for packaging rice, grains and other materials. It can be generally recycled for packing fresh produce.  
                          • Key advantages are ready availability and cost effectiveness.                               |
| Plastic bags         | • Made from polyethylene films.  
                          • Commonly used for transporting highland vegetables such as lettuce, broccoli, cauliflower, cabbage, carrots, etc. to wholesale markets in urban centers  
                          • They are relatively inexpensive, readily available and have a low weight to volume ratio |
| Plastic Crate        | • High quality plastic crates, with proper venting, which are stackable, nest-able, easy to clean and reusable are used extensively for storage, post-harvest, handling and transportation |
| Containers           | • Reusable plastic containers protect the produce from mechanical injury, and contamination during marketing. |
| Plastic films        | • Help in reduction of moisture loss from the product, which is a principal requirement of limited permeability packaging materials. |
| Plastic Cushioning Materials | • Commonly used cushioning materials are moulded plastic trays, foam plastic sheet, plastic bubble pads, plastic film liners or bags  
                                         • Prevent commodities from mixing, when there is a vibration or impact. |
| Plastic Sheets       | • Plastic sheets are spread below the tree being harvested to collect the nuts / fruits.          |
| Plastic Pallets      | • Plastic pallets are widely used in moving the loads of cartons                                  |

**Plastic applications in Packaging:**

Major application of plastics in food products is in packaging. Plastics are preferred for its characteristics and versatility of applications. It is lightweight, corrosion resistance, moisture proof, highly versatile and can be moulded into attractive shapes. Additionally, packaging standards have become more stringent with introduction of new Indian norm closer to global standards which are also driving the use plastics in packaging.
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</tr>
<tr>
<td>Plastic Pallets</td>
<td>Plastic pallets are widely used in moving the loads of cartons.</td>
</tr>
</tbody>
</table>

Both flexible & rigid packaging is used in processed foods. Flexible packaging consists of either monolayer or multilayer films of plastics. Multilayered laminated sheets of plastics mainly include PE, PP, PET, and PVC. Polyethylene and polypropylene account for ~ 62% of polymer usage in the flexible packaging industry (Ref: Fig 16). Flexible packaging is dominated by small & medium sized companies. The Indian packaging industry is expected grow at 15% p.a.with flexible packaging growing at 17% p.a. and rigid growing at 14% p.a.(Ref: Fig 17).

Figure 15: Plastics in flexible packaging (% share)

Figure 16: Indian packaging industry growth projection (USD billion)
Uttarakhand (Haridwar, Rudrapur & Pant nagar) is one of the key packaging clusters in India. 13% of the total organized flexible packaging is from this region. The major players who are present here are: Essel Propack, Paper Products, Radha Madhu Group & TCPL.

With rising personal income, changing lifestyle, growing awareness and upcoming innovations in the post-harvest management system, the use of plastics is expected to grow at a high rate in this region as well.
VII. Factors promoting opportunity in Northern India

IOCL Panipat plant and HMEL Bhatinda plant has given an impetus to feedstock availability in Northern India which had minimal access to feedstock. Besides this IOCL has also commissioned a propylene recovery unit at its Mathura Refinery and is expected to invest Rs. 30,000 crore to increase its presence in petrochemical industry. GAIL also has plans to double its capacity which will further make the feedstock scenario more promising in Northern India. These will lead to increased investments in downstream plastic processing.

The macroeconomic trends for increase in demand of end use industry are more likely to impact regions of Northern India and Eastern India than rest of India. These two regions are in a growing phase and are facing significant change in lifestyle and in turn growth of domestic end use industries.

India's increased focus on manufacturing is likely to provide boost to downstream plastic processing industries in Northern India too. Increasing urbanization, changing lifestyle and demographic dividend, greater consumer spending for items that require plastics - from packaged goods to mobile phones and automobiles etc. are also the factors promoting the opportunity of downstream plastics. Especially in Northern Indian states and near-by states of Bihar and Jharkhand, the lack of plastic processing industries presents a huge unmet opportunity potential.
Moreover, National Committee on Plasticulture Applications in Horticulture (NCPAH) has the mandate to promote and develop the use of plastics in agriculture, horticulture, water management and other allied areas.

On the recommendation of NCPAH, the Government has also established 22 Precision Farming Development Centres (PFDCs) all over the country to promote various plasticulture applications in horticulture by undertaking trials, seminars, workshops etc. These PFDCs are located in State Agricultural Universities (SAUs); ICAR Institutes such as IARI, New Delhi; CIAE, Bhopal & CISH, Lucknow and IIT, Kharagpur. Presently 22 PFDC have been operating.
VIII. Challenges for plastics industry in Northern India

1. **Addressing environmental myths**

While the usage and benefits of plastics are manifold, it invariably gets branded as a polluting material. However, it cannot be overlooked that the bans or restrictions on plastic packaging can impact various industries. The study conducted by FICCI reveals that these bans may impact the plastic industry sales of Rs. 53,000 crores and nearly 13 lakh personnel.

It is important to address these myths regarding the polluting characteristic of plastics. Plastics are chemically inert substances and they do not cause either environmental or health hazards. If plastics can be collected and disposed of, or could be reused by infusing various tested technologies like polymer blending in bitumen roads and co-processing in cement kilns or even recycled as per laid down guidelines/rules then the issue of plastic waste can be suitably addressed. In fact there is wide scope for industries based on re-cycling of plastics waste.

2. **Technology needs**

Technology needs are not particularly pertinent only to Northern India; they are the common need across India. The Indian Plastic processing industry has seen a shift from low output/low technology machines to high output, high
technology machines. There has been some major technological advancement of global standards leading to achievements like:

- World’s largest integrated Clean Room FIBC manufacturing facility
- World’s largest water tank manufacturer in India. The Indian market is world largest market for rotomolded water tanks.

However, India’s technology needs are critical in areas like high production and automatic blow molding machines, multilayer blow molding, Stretch/Blow Moulding Machines, specific projects involving high CAPEX like PVC calendaring, multilayer film plants for barrier films, multilayer Cast lines, BOPP and Nonwoven depend solely on imported technology/machinery. Other technological needs are:

- Multilayer blown film line up to 9/11 layers
- Automatic Block bottom bags production line
- Higher tonnage Injection Moulding machine >2000 T
- Higher tonnage >500 T all electric Injection Moulding machines

3. Price pressure

The profits of plastics processing industry is facing tough times because of increased & volatile input prices. Increase in crude oil prices along with the continuous fall in rupee value has led to lower profits in spite of higher volume realizations.
IX. Recycling & Waste Management of plastics

Recycling of plastics is one of the foremost steps towards innovation and sustainability in this industry. Currently in India, number of organized recycling units for plastics is ~ 3,500 along with additional ~ 4,000 unorganized recycling units. Most of the plastics (PE, PP, PVC, PET, PS,) etc. could be recycled via mechanical route. Whereas, engineering plastics like PBT, SAN and Nylon etc. are recycled by selected recyclers. In India, recycling of plastics is currently 3.6MnTPA and it provides employment to almost 1.6 Million people (0.6 million directly, 1 million indirectly). The following figure shows the typical plastic recycling method. (Refer Figure 18).

**Figure 17: Plastic recycling flow diagram**

[Diagram showing the recycling process with steps like Plastic waste, Material recovery, Energy recovery, Mechanical recycling, Feedstock recycling, Biological recycling, Conversion to monomer, Conversion to fuel, Reducing agent in furnace, Gasification, Cement kiln, Heat & Power generation]

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Knowledge Paper on Plastics Industry
The collection & segregation of recyclable waste is one of the key steps in taking this further. Many a times, households and establishments throw the waste on the street or dump it in open without segregating the waste which reduces the quality and at times could make it hazardous. It is essential to save the recyclable waste material from going to the waste processing and disposal sites and using up landfill space. Salvaging it at source for recycling could make profitable use of such material. This will save national resource and also save the cost and efforts to dispose of such waste. An optimum way to achieve it is by forming a habit of keeping recyclable waste material separate from food waste and other bio-degradable wastes, in a separate bag or bin at the source of waste generation, by having a two-bin system for storage of waste at homes, shops and establishments where the domestic food waste (cooked and uncooked) goes into the Municipal Solid Waste collection system and recyclable waste can be handed over to the waste collectors (rag-pickers) at the doorstep for transporting the same to the recyclers.

The Life Cycle Analysis of various plastics products reveals that plastics create lesser environmental pollution in the atmosphere compared to the alternatives. Energy consumption, emissions of Green House Gases like CO2 and CH4, quantum of water usage - in all parameters plastics create lesser foot print on earth.

Currently, less percentage of plastics produced is used for recycling whereas the potential is much higher. As plastic consumption is expected to grow at more than 8% CAGR for the next 5 years, the scope of recycling of plastics is huge.

Some form of plastics like plastics in packaging applications, plastics for some one-time use - like cups, plates etc. create waste management problems when the discarded plastics materials are not disposed of properly. Very thin plastic bags, though recyclable, are often left behind by the waste pickers due to economic reason. To avoid this problem, MoEF, Government of India had come up with rules in September 1999, restricting the thickness and size of plastic carry bags. These Rules have undergone modifications in June 2003 and later in 4th February, 2011 amended 2nd July, 2011. In the
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Going ahead it is expected that the awareness of consumers and support from government is likely to increase the recycling of plastics and increase the magnitude of plastic waste management.
X. Conclusion

Commodity plastics comprising of Polyethylene (PE), Polypropylene (PP), Polyvinyl Chloride (PVC) and Polystyrene account for bulk of the plastic consumption in India. India has ramped up its production capacity for plastic to reach 2.9 MnTPA for PE, 3.1MnTPA for PP and 1.4MnTPA for PVC. IOCL Panipat refinery, HMEL Bhatinda plant and upcoming GAIL capacity expansion at Auriya will increase the supply of plastics in Northern India. With increased supply of plastics, the focus should now be on the downstream plastic processing industries and how do they grow profitably.

There are several factors like low per-capita consumption, manufacturing focus, end use industry growth, availability of feedstock, increasing urbanization, changing lifestyle, demographic dividend etc. promoting growth of plastic across India. However specific to Northern India we observe a lack of planned downstream plastic processing plants within the region and near-by regions of Eastern India to make use of these factors. Spill off benefit of promoting plastic processing is the huge inherent employment potential.

Many application areas of plastics also have overlaps that make market driven material substitution a good possibility. There are strategic objectives driven by part consolidation and sustainability compulsions by the user industry that have made material selection converge to a polymer to promote recycling. An organized development addressing cost effective plastic processing along with streamlining operations of recycling of plastics could pave a growth path for downstream plastic manufacturers in Northern India.

Plasticulture, which is in its infancy in India, can significantly benefit agriculture by its wide applications in all the areas of farming. It can be used to tackle the specific problems faced by North Indian regions. There exists an opportunity in the same field as the demand of Plasticulture will rise in order to ensure efficiency and sustainability of agriculture practices.

Applications of plastics in micro irrigation and post-harvest management can also give a new extension to the growth of plastic industry. Moreover, post-harvest chain comprises of a number of stages for the movement of
harvested output from the field to the final retail market. There are lots of chances for the degradation of food quality. Unique properties of plastic make it suitable for applications such as packaging, storage etc during post-harvest management.

Application of plastics in food processing industry is poised to grow at a good rate. With the change in lifestyle, income levels and aspiration, the growth in the food processing sectors is expected to be very high. As plastics are majorly used for packaging such products, their demand is also expected to grow. North India is already a hub for food processing companies with major international players running their operations thereby promoting the consumption of plastics.
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XII. Innovative Plastics-based Solutions for Alleviating Water Scarcity in the Northern India*

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Surplus grain production in Punjab and Haryana is central to the national food security as it meets the food deficits of several other states. Regional land and water productivity of both rice and wheat, as assessed through remote sensing products and other modelling exercises, at levels of above 1.28 kg/m³ is one of the highest in the country. This is quite commendable. However, these large positive benefits have also created alarmingly high negative hydrological conundrums. Mainly the crop evapotranspiration but also other sectors, after scavenging every drop of the available rainfall, runoff, canal supplies and groundwater recharge create an annual net negative balance of about 6 m ha-m in Punjab alone. This is causing a continued steep and widespread decline in water tables (sometimes more than 1-2 m/annum) and the state is labelled as "over-exploited" by the national agencies and "a global hot spot" by the international resource monitors. The existing national policies on food procurement and energy subsidies aimed at higher production also cause depletion of diminishing resources. In case, urgent and innovative solutions are not implemented at a scale in the region, the much acclaimed model of the green revolution may soon become hydrologically unsustainable. Some innovative solutions are given below:

1. Recent research by International Water Management Institute along with its partners and several other institutions has shown several opportunities. The first is to adopt for suitable Managed Aquifer Recharge Structures on a large scale. Analysis of Sangrur district showed that whereas pre-monsoon depth to water table was between 8.77-23.89m, the post-monsoon levels were 9.95-24.52m indicating a net discharge of aquifer by 0.47 to 0.76 m. Rainfall runoff from non-agricultural lands (about 400 km² in the district) provide a good resource
to be channelled into local ponds for artificial recharge. Such ponds are generally available in the close vicinity of most of the villages. A well-designed scheme on Managed Aquifer Recharge may be implemented to augment the depleting resources.

2. The northern region of India is surrounded by the water sufficient and beautiful states of Jammu & Kashmir, Himachal Pradesh and Uttarakhand. These states have limited cultivated area but surplus amounts of rainfall during the rainy season. The cool climates are highly suitable for off-season vegetables, fruits, traditional and exotic herbal medicinal plants and floriculture, mushrooms and a variety of timber and other high value crops. Besides connectivity, infrastructure and aggregating markets; the major limitation is the non-availability of adequate water storage and use facilities, as most of the surplus rainfall and is lost as surplus runoff. Plastics have shown a great promise in the region through construction of polythene lined tanks under individual and community ownership. These tanks situated on the terraces supply water under gravity and can be connected to low head drips and micro-sprinklers and do not need any additional energy. For smaller water needs low capacity plastic lined Jalkunds (water cisterns) have been developed which directly harvest the rainwater. In hilly areas, plastic storage and pipelines have also been designed for the Multiple Use Water Systems which integrate the domestic and irrigation water needs and draw their year round supplies from water springs, streams and other sources. Bucket or drum kit based plastic drip systems are also available to meet small but critical needs of the farmers engaged in high-value diversified agriculture. Successful models are also now available with plastic lined trenches which harvest rainwater and are most suitable for the cultivation of horticulture, medicinal and aromatic plants and fast growing timber plants.

3. The state-wide analysis of the impact of delayed transplanting of paddy in Punjab (and Haryana) showed that a net ET gain of 14 mm to 90 mm could be obtained by a delayed transplanting of 1 to 6 weeks.
the whole rice cropped area (2.62 M ha) of Punjab followed the stipulated provisions, the net water savings of 2,180 million cubic metre were achieved resulting in a saving of 7% in annual groundwater draft. Additionally, this will lead to a saving of 175 million KWh of energy. The study further recommends that rather than a single way of responding; delayed transplanting ought to be integrated with other demand management options for added gains.

4. **Linking canal commands with plastics lined tanks (Diggis)** have proved a major boon for the farmers in the arid areas of Indira Gandhi Nahar Pariyojana (IGNP) in Rajasthan. As groundwater are highly saline, the farmers are solely dependent upon the fresh water supplies from the canals. Unfortunately the canal supplies are uncertain and erratic due to canal management inadequacies. Additionally, a large part of the water gets wasted due to highly sandy and undulating soils. The optimum solution under these constraints was to collect and store the water in plastic lined diggis and apply to the farms as per need through plastic pipes and sprinkler/drip systems. The initial models and demonstrations have shown a great promise and now need to scaled up through industry-government-farmer partnerships.

5. Diversification of agriculture through enhanced integration of dairy has significant positive impacts on water footprints and economic gains. A case study for Moga district revealed that rice, wheat and forage crops comprise more than 99% of the annual cropped area. Groundwater contribution to the total annual consumptive water use (CWU) - 94% of 1,461 million m$^3$ - is so large that groundwater embedded in the production surpluses of rice, wheat and milk alone exceeds the estimated groundwater recharge in the District. The groundwater CWU in rice production is 1.7 to 2 times higher than those of milk and wheat, and the financial value of the output of rice-wheat-milk production system is 10 and 27% lower than that of the milk-wheat and milk-only production systems respectively. Thus, the intensification of dairy production, with a calculated reduction in rice area to compensate for increasing requirements for green fodder, can bring the groundwater depletion to
sustainable limits, while producing a surplus of rice for export. The optimum combination is to change annual cropping pattern of rice, wheat and fodder crops to 62, 90, and 42% of the net irrigated area from the present level of about 90, 90 and 20% respectively, and double the lactating dairy animals to 8 per 6 ha of land. There are several plastics based interventions in this crop-dairy-milk value chain which save both precious water and provide higher and sustainable incomes to the farmers. Even a partial adoption of this recommendation has huge financial and hydrological benefits towards a sustainable agriculture in these state.

6. With provision of household sanitation in the rural areas (And also in smaller towns) the safe disposal and use of wastewater has become a huge problem. Presently, it runs through drains and streets/lanes in the villages and finally gets collected in the village ponds and depressions in the villages and poses a major health hazard. Additionally, the only fresh water bodies in the villages and towns which used to provide a number of ecological and aesthetic services to the villages have now become stagnant cesspools of wastewater polluting the aquifers and hand pumps which are generally the only source of drinking water in these vast areas. There is a good potential of developing plastics based Resource Recovery and Reuse Models where fresh water and waste water sources may be segregated and the waste water may be collected in plastic lined tanks and safely used for high value agriculture after the primary treatments. The sludge and residues collected at the bottom of these waste water lined ponds shall be a good source of organic fertilisers to restore the soil health and boost productivity.

7. The new innovations of solar powered pumps, ground water markets, freshwater aquaculture, protected and precision agriculture, small but intensive and high value farms (also called Lakhtakiya farms) cultivating strawberries, baby corn, celery, lettuce, cherry tomatoes, organic farms, rooftop gardens and other commodities required by high-end customers and hotels/ restaurants all require regulated and precise applications of agricultural inputs, advanced care and harvesting,
packaging and transportation of the perishable produce. This is possible only through improved and enhanced use of plastics through development of specific products and designs. Good research and demonstration in all these aspects shall spurt the sustainable and safe use of plastics in the production and value chain and create a win-win situation for the plastics industry and enhancing and improving the livelihood options for progressive farmers and smart entrepreneurs.

The present model of agriculture and water use is stuck with an intensive resource input based low-value unsustainable cereal production. As accelerated cereal production picks up in other regions, the northern region may envision a new paradigm of high value and diversified sustainable agriculture and sustainable water use. The region already have the competitive advantage of complete coverage of its farms under irrigation, machinery and farm energy; excellent infrastructure and markets, a progressive investment climate, knowledge institutions and great human resource. The plastics based innovative solutions, besides the traditional interventions already well known, shall synergise the growth of plastics industry and also enhance the incomes and livelihoods of those engaged in the production systems and a better value for the large consumers. The moment has now arrived for chartering a new trajectory.
Packaging and transportation of the perishable produce. This is possible only through improved and enhanced use of plastics through development of specific products and designs. Good research and demonstration in all these aspects shall spurt the sustainable and safe use of plastics in the production and value chain and create a win-win situation for the plastics industry and enhancing and improving the livelihood options for progressive farmers and smart entrepreneurs.

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गाजीपुर हिमणी हुई उद्देश्य अन्तर संहत हिम उद्देश्य घरानिया नामा चर्चा गैर था विषय माल मुक्त ती गैरीरी रंग थे रंग भवन लिंग तमल उंच पूंछ मरी अपने उड़ान मै लक्ष्य का आसाम ही अंत हे ब्रह्म रंग अनुमोदन में अंत हे हवाओं रंग है अनुमोदन है उड़ान मै लक्ष्य हो वहा उपभाषा अंतर्गत का सियाह था। ब्रह्मविज्ञान गाजीपुर हिमणी लिंग उड़ान पंचवीं थे। अंतर्गत सियाह था। किसी ली उड़ान गाजीपुर हिमणी रंग अंतर हिमणीया नामा है अलो तिथि प्रवीण गाजीपुर हिमणी हुई उद्देश्य ब्रह्मविज्ञान है।

गाजीपुर हिमणी लिंग उपभाषा द्वारा बीतोते

प्रभाष दे भिले-सुकु द्वारा हिमणी लिंग, भवन भगीरथ दा उपभाषा बेकी 30 किलोमिटर मैलमित्र मूला था। नारील बंद गैरीगौरी जो अंतर उड़ान दा उपभाषा 38 किलोमिटर मैलमित्र मूला था। सिवि अंतर वृत्तिया लटी तवारालिखित है। नारील अतिहाद के भगीरथ दे हिमणी लिंग घर मै उड़ान दा उपभाषा 33-35 किलोमिटर मैलमित्र मूला था। नारील बंद दे भगीरथ दे हिमणी घर मै उड़ान दा उपभाषा बेकी 30 किलोमिटर मैलमित्र मूला था। नारील अतिहाद के भगीरथ दे हिमणी लिंग घर मै उड़ान दा उपभाषा 38-40 किलोमिटर मैलमित्र मूला था, भगीरथ दे भगीरथ दे हिमणी लिंग घर मै उड़ान दा उपभाषा 38-40 किलोमिटर मैलमित्र मूला था। नारील अतिहाद के भगीरथ दे हिमणी लिंग घर मै उड़ान दा उपभाषा 38-40 किलोमिटर मैलमित्र मूला था, भगीरथ दे भगीरथ दे हिमणी लिंग घर मै उड़ान दा उपभाषा 38-40 किलोमिटर मैलमित्र मूला था।
संपत्ति है। एक्स उद्योगी त्रिकोण डीजीडीवैक्सल अपने अप डिग्री डिंग सममिट है।
समय केन थाँकता तनी है। समय के गुमरण डिंग गाइड राइम डिंग तमी ती माउड़
वेट विश्वास चे मंत्री है। क्रिम राइम डिंग इमर्गेंग्ज तप्ती उद्योग आणि जागरण
टिज हरी सामाजिक रेडियो अम्लभी चे मंत्री है। गाइड राइम तस्में
ग्लास उद्योगी तमी ती माउड़ हूँ खटखट डिंग अम्लभी चे मंत्री है। गाइड राइम तस्में
उद्योगी तमी ती माउड़ हूँ खटखट डिंग अम्लभी चे मंत्री है।
क्रिम राइम गाइड राइम लोक लेज़र डिंग के भविष्य अपे
पूर्वसन्धी डॉलिंग तरी जिमे गाइड राइम तस्में भिल चे भांड़ अंदे अंदे उष्णकाल गेट भविष्य नाचे उड़ ने कैमरन वेलीवलय भिष्म इंग्लै प्रिंग
तिमी संपत्ति समग्र, टिम्सेंड अपे सत्तां ने मंडीरकर ती सिध्दांत जबकी
क्रिम राइम तस्में ग्लास गाइड राइम/पेकी राइम लोक लेज़र डिंग चे मिनमुड़ पिंडी चे।
XIV. About Tata Strategic

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.

Tata Strategic offers a comprehensive range of solutions covering Direction Setting, Driving Strategic Initiatives and Implementation Support

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About FICCI

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 organization, 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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50 Knowledge Paper on Plastics Industry

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