

Population Growth and Materials Demand Study

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Population Growth and Materials Demand Study

1 Introduction

Over the next 30 years, the world population will approach 10 billion which is an increase of more than 25% adding more than 2.5 billion people primarily in Asia and Africa. At the same time, as people around the world continue to work to improve their standard of living, demand will increase for food, water, more comfortable housing, transportation, infrastructure, consumer goods (e.g. electronics, appliances, leisure and sporting goods, etc.), and other modern conveniences available to people in middle and higher income levels today. Population growth and improvements in global standards of living will fuel demand for all types of materials such as wood, paper, steel, aluminum, concrete, glass and plastic.

The use of plastic has delivered many benefits for consumers and society and is essential to humans achieving their living standard objectives over the next 30 years. Plastic packaged food and beverages last longer, reducing waste. Plastic pipes enable clean water supply. Plastic is used in medical applications such as surgical equipment, drips and blister packs for pills. Due to its light weight, plastic use in vehicles has reduced carbon emissions. Plastic is one of the most versatile, useful and important materials in modern society.

The production of plastic to meet global demand is driven by low cost raw material supply where North America now has a leading position due to abundant natural gas. Resin in the form of pellets is easily transportable through a highly efficient supply chain that facilitates exporting of product from low cost production locations to areas of demand. Furthermore, from a global perspective, not only is low cost important, but it is better for the environment to manufacture a product in a region with highly efficient and safe production facilities, more stringent environmental policies and where good manufacturing practices are followed.

This report provides context around global increases in plastic use by highlighting the needs of a growing global population and the wide scale movement out of poverty and into the middle class. The drive to improve the human population's standard of living will alleviate suffering while increasing demand for all sorts of goods and packages, affecting demand not only for plastics, but all types of materials.

Existing research (e.g. environmental cost accounting¹ and life cycle analysis²) demonstrates that using plastics instead of alternative materials for many of these goods and packages will help reduce society's environmental footprint and contribute to sustainability efforts.

This report:

1. Identifies and describes global megatrends, focusing on those that will affect the future demand for consumer spending in general and the use of plastics products and goods that contain plastics as well as other materials.
2. Models how changes resulting from the megatrends (e.g. increases in population and income) will create increased need and demand for things like food, drinking water, personal care products, health/medical care, fuel-efficient cars, energy-efficient homes, connectivity, etc. – all things that help people live safer, healthier and longer lives with lower environmental impact that plastics provide compared to other materials.
3. Projects demand for other materials (steel, cement, paper, wood, aluminum, glass, etc.) showing that the growing population and increased wealth will create greater demand for everything, not just plastics.

¹ Plastics and Sustainability: A Valuation of Environmental Benefits, Costs, and Opportunities for Continuous Improvement; Trucost, July 2016. See: <https://plastics.americanchemistry.com/Plastics-and-Sustainability.pdf>

² Life Cycle Impacts of Plastic Packaging Compared to Substitutes In the United States and Canada: Theoretical Substitution Analysis; Franklin Associates, November 2018. See: <https://plastics.americanchemistry.com/Reports-and-Publications/LCA-of-Plastic-Packaging-Compared-to-Substitutes.pdf>

2 Global Megatrends

Megatrends are long term, far reaching, sustained, macro-economic forces of change that impact cultures, society, economy, business and personal lives thereby defining our future world and its direction and pace of change. They have different meanings and impacts for different regions, countries, industries, companies and individuals.

They bring radical change to political, social and economic spheres and analysis of these trends and their implications forms an important component of an entity's strategy, planning and development. Megatrends set the stage for visionary thinking by defining a future state and the implications resulting from these trends in transforming our world.

The following criteria were considered in selecting the critical few megatrends on which to base this study:

- Long-lasting, occurring over at least the next 10 years, and ideally much longer.
- Global in nature, affecting all regions and countries to some extent.
- Impact all economic sectors to some extent, though sector-specific effects may vary widely.
- Strong enough to affect global economic, social, governmental, and environmental systems.
- Will change the functioning and structure of the affected systems.
- Will affect consumer consumption preferences.

The following four megatrends were selected based on the above criteria and form the basis for this report. They enable us to first identify the appropriate economic variables and then gain a sense of magnitude and regional distribution of impacts on materials demand by variable.

1. Population Growth and Mix (i.e. Global Demography)

The shifts in global demographic trends (e.g. number of people, age distribution, regional growth rates, etc.) will have a direct impact on local environments including resource consumption. As an example, the world population is expected to approach 10 billion people by the year 2050 growing from about 7.5 billion currently.

An increasing number of people in the world will need more food, clean drinking water, shelter, energy and waste management to name a few necessities to survive. Increasing numbers of people in certain age groups will require different types of products and services. As an example, as people live longer, an aging population will require different and more health and medical care.

2. Rise of Middle Class

The emerging market population is expected to grow from 3.7 billion in 1990 to 6.3 billion in 2050 with a large percentage of people projected to move out of poverty and into the middle class. By the year 2030, the world will add more than 400 million households to the growing middle class.

With increasing income and purchasing power more people will be looking to improve their standard of living. Some of the expected added demand from this growing middle class includes:

- More healthful food along with the convenience of packaged food
- Improved health and medical care – medical devices as well as disposable service items
- Increased demand for consumer goods – electronics, appliances
- Availability of more energy efficient housing and transportation

3. Urbanization

From the year 2000 through 2050, there is expected to be an increase from 48% to 68% of the world's population (an additional 3.1B people) living in a city or urban environment.

Consumption implications from this shift result in increased demand for comfort and efficiency due to the limited physical space and more people being pressed for time (looking for ways to simplify their life) as they move from a rural setting to an urban lifestyle.

The migration from rural to urban will have a huge impact on the need for:

- Greater amount of food transported from farm to urban areas with reduced spoilage
- Infrastructure development including roads and buildings, electricity distribution, sewer and water supply, gas distribution for cooking and heating, etc.
- Energy efficient automobiles/transportation, housing and appliances
- Growth in high-tech sectors that enhance the comfort/efficiency in urban life (e.g. consumer electronics, interconnectivity, etc.).

4. **Sustainability**

The use of plastic has reduced the environmental impact in a variety of applications while providing added benefits that help people live better lives.

When using plastic vs other materials:

- food lasts longer, reducing waste and preserving freshness
- pipes are less expensive, lighter weight and will not rust or corrode for the supply of clean drinking water and distribution of gas for heating and cooking
- vehicles are lighter in weight enabling better fuel economy and reducing carbon emissions

Without the growing use of plastic, there would be an unsustainable demand for other material needed to provide the same functionality as plastic in a variety of consumer goods segments. For example, alternate packaging material for soft drinks and ice would require more than 7 times the weight of plastic packaging used today, and food packaging would require more than 4 times the weight of plastic packaging used today.

Other megatrends were considered but not specifically included. However, some can be thought of as derivatives of the four selected for this study. Examples of other important megatrends are:

- **E-Mobility:** A rapid rise in electric-powered drivetrains designed to shift vehicle design away from the use of fossil fuels and carbon emissions is expected around the globe. E-Mobility will bring a new set of players offering an innovative and customized set of infrastructure and technology solutions including new materials like plastics that offer further light weighting and improved performance opportunities.
- **Infrastructure Development:** Emerging transportation corridors will lead to growing economic and technology clusters along these corridors. These integrated hubs will be the future centers of innovation, R&D and technical excellence attracting significant investment and government support. They will follow along with an increasing population, growing urbanization and general drive for people to improve their standard of living.

3 Economic Variables and Commodity Material Demand

3.1 Introduction

Description of Economic Variables

The economic variables used in this report are gathered at the country level, then aggregated to represent the regions of interest. Population growth is measured as the change in population as reported by the United Nations. Also considered as a variable related to population is the total number of households.

The US Census Bureau defines households as consisting of all people who occupy a housing unit, such as a house or apartment. A household includes related family members and all the unrelated people who share the housing unit. Most countries and agencies define households in a similar way. The source of data on number of households is IHS Markit.

The economic variable used to determine the rise of the middle class is the percentage or number of households in a region whose yearly income falls between \$15,000 to \$150,000 constant 2015 US PPP\$ (PPP = purchasing power parity – the income level needed in the other countries that would be required to have the same purchasing power as in the US). To calculate this variable, income data sourced from the World Bank was used for history with forecasted income data from IHS Markit. A person is categorized in the middle class if they earn between \$10 to \$100 per day in constant 2005 US PPP\$. The constant 2005 US PPP\$ figure is converted to constant 2015 US PPP\$ to match the scale of other income data by using a consumption price deflator. Purchasing power parity (US PPP\$) is used to account for the varying cost of goods in different countries and avoid variations from exchange rates between and within regions.

This report consolidates individuals into households. Considering a household rather than a person is based on the premise that the demand for and consumption of plastic and other items is driven by household decisions. Assuming there are 4 people per household and converting daily income to annual income results in the middle class being defined as a household whose annual income is between \$17,343 and \$173,435 in constant 2015 US PPP\$. Due to the income brackets in the IHS Markit database, the middle-class income is rounded to between \$15,000 and \$150,000 constant 2015 US PPP\$. High income is therefore greater than \$150,000 and low income is below \$10,000 constant 2015 US PPP\$.

Urbanization is represented by the percentage of a region's total population living in an urban area. An urban area is defined based on each individual country's criteria. The source of the urban population and total population in millions of people per region for history is from the World Bank and the United Nations and the for forecast is from IHS Markit.

Other economic variables analyzed include GDP and the consumption of durable and non-durable goods by households. The consumption of durable and non-durable goods is measured as thousands of constant 2015 US dollars. A durable good is defined as one that may be used repeatedly or continuously over a period of more than a year, assuming a normal or average rate of physical usage. Examples of durables include furniture, therapeutic appliance and equipment like eyeglasses, and automobiles. A nondurable good is used up entirely in less than a year, assuming a normal or average rate of physical usage. Some examples of nondurable goods are pharmaceutical products, stationary, food and beverages. Historical consumption data is collected through primary national statistical sources or, if not available, from the United Nations. Forecast is provided through IHS Markit. Because consumption is typically made at the household level, we consider the consumption of durable and non-durable goods per household.

GDP is reported in thousands of constant 2015 US dollars per household and is sourced from the United Nations for historical figures and from IHS Markit for the forecasted years.

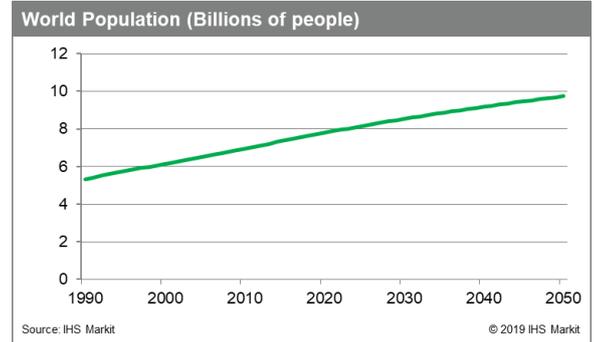
Description of Commodity Materials

Commodity materials data is provided mostly through IHS Markit's Comparative Industry Service (CIS). CIS uses the United Nation's International Standard Industrial Classification (ISIC) codes to categorize apparent consumption, among other concepts of economic activity. For purposes of this report, we collect data on apparent consumption in terms of millions of 2010 US dollars for wood, paper, glass, cement, and steel. The historical data comes from multiple sources including United Nations, Organization for Economic Co-operation and Development (OECD), and national statistical agencies. The source of the forecasted figures is IHS Markit. Aluminum history and forecast through 2029 is sourced through the World Bureau of Metal Statistics (WBMS) and is provided in units of metric tons of consumption at the country level. Country consumption is aggregated to calculate regional consumption.

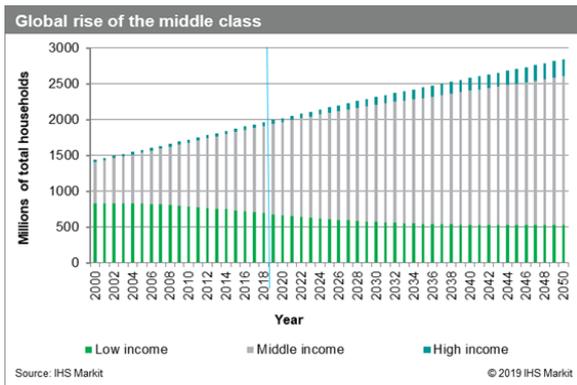
3.2 Global Trends and Forecast

Population

While the overall world population growth is slowing, there will still be a large increase in the number of people in the world between now and 2050. The world population growth rate is expected to drop from 1.2% / year in 2000 to 0.4% / year in 2050 with some countries and regions experiencing a decline in population while others continue to grow all be it at a slower pace. Overall, the world is expected to see an increase in global population of about 2.5 billion people over the next 30 years.



Middle Class

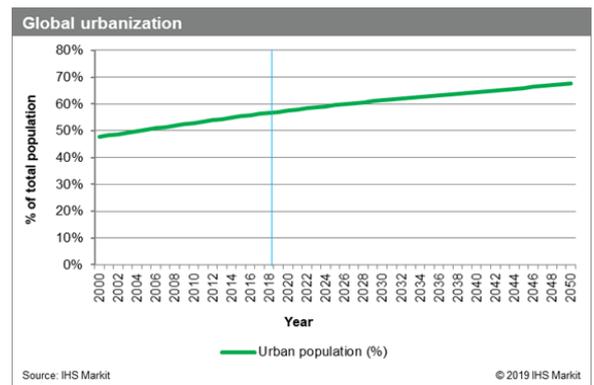


Since 2000, the number of middle class households has climbed globally. In 2000, about 40% of households around the world, close to 580 million households, were classified as middle class. By 2018, over 62% of households, or over 1.2 billion households, belonged to the middle class, a compound annual growth rate of number of middle class households of 4.0%. In the future, we forecast the rise of the middle class to go on but at a slower rate until an eventual plateau by 2030 to 2050. Although the percentage of middle class households globally is stable in the forecast, the number of households increases in this period meaning the total number of households in the middle class is increasing. In 2030, we forecast over 1.6 billion households in the middle class and in 2050 this

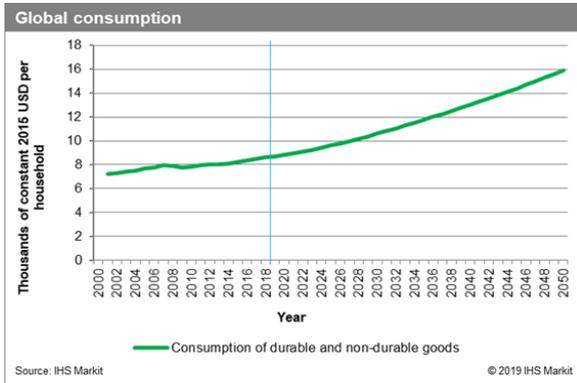
increases to almost 2.1 billion middle class households.

Urbanization

The promise of jobs and prosperity, among other factors, pulls people to cities causing urbanization. At the global level, the movement of people from a rural environment to an urban setting (i.e. urbanization) has been steadily growing and is predicted to continue on a similar growth path. From 2000 to 2018, the percentage of the total world population defined as living in urban areas increased from about 48% (2.7 billion people) to almost 57% (3.9 billion people), an annual increase of roughly half a percentage point per year. Between 2019 and 2023, we forecast the compound annual growth rate of global urbanization to be around 0.6%. From 2019 to 2029, the population of the world living in urban areas will increase from close to 4 billion people to about 4.6 billion people. Beyond 2030, the growth of urbanization is forecasted to be a constant steady rise resulting in an overall increase of 3.1 billion people living in an urban environment in 2050 compared to the year 2000 level.



Consumption

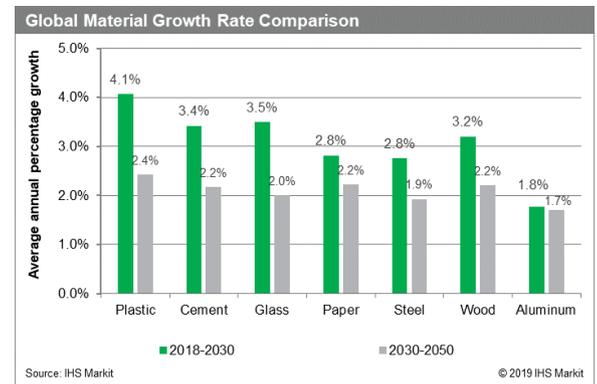


Global consumption of durable and non-durable goods has generally experienced slight growth since 2000 with the average household spending about \$7,240 constant 2015 USD. Consumption spending on durable and non-durable goods rose to \$8,700 constant 2015 USD in 2018, a compound annual growth of about 1% per year. During the 2008 Recession, consumption dipped slightly, but began to climb again in 2010. We forecast consumption of durable and non-durable goods to climb at a faster growth rate in the future due to rising disposable income, a growing middle class, and global movement to urban areas. In the next ten years, the compound annual growth rate is expected to be about 1.6%. Beyond 2029, we forecast that spending on durable and non-durable goods will rise at

a faster pace eventually reaching \$15,900 constant 2015 USD in 2050.

3.3 Relationship with Material Demand

As with plastics, other commodity materials are expected to experience similar growth over the next 30 years following from the megatrends described above. Other commodity materials considered in this report include aluminum, cement, glass, paper, steel and wood. Because the demand for non-plastic commodities are driven by the same megatrends that affect the demand for plastic, the demand for these commodities will rise as population grows globally, more people move to urban areas, the number of middle class households increases, and consumption of durable and non-durable goods climbs over time. Compared to the other materials, the demand for plastic will grow at one of the fastest rates due to its versatility, performance advantages and overall environmental benefits. Other commodities with similar growth rates include cement, glass, and wood. The metals, aluminum and steel, are forecast to be the slowest growing of the materials considered. The reason for this is, prior to 2015, emerging markets experienced rapid industrialization and increased the demand for commodities. Much of the demand in this period was driven by China, where the emphasis on infrastructure, investment in heavy industry, and exports shaped its economy. However, the level of consumption of these commodities cannot be sustained in the future. As population growth slows and economies mature globally, demand for commodities will slow.



4 End Use Plastics Demand

4.1 Introduction

This study includes the major volume plastics of Low Density Polyethylene (LDPE), High Density Polyethylene (HDPE), Linear Low-Density Polyethylene (LLDPE), Polypropylene (PP), Polyvinyl Chloride (PVC), Polystyrene (PS), Expanded Polystyrene (EPS) and Polyester Terephthalate (PET). The volumes for each plastic includes prime/virgin polymers as well as post-consumer recycled polymers; in addition, the volumes reflect IHS Markit's current view of the impact on demand from the sustainability megatrend discussed above. The country/regions of Africa, China, Europe (EUR), India, North America (NAM), South America (SAM) and Southeast Asia (SEA) are the focus of the study representing a large majority of the world demand (>85%) and covering the key growth regions for the future.

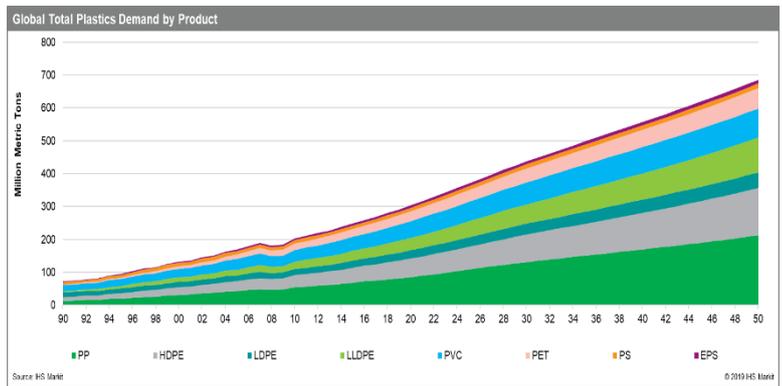
The demand for polymer within each country/region was adjusted using the ratio of “apparent consumption” and “gross output” as reported in the IHS Markit Comparative Industry Service to more accurately account for converted resin which is subsequently exported from one region and consumed/used in an importing region. This adjustment provides a more accurate view of domestic consumption thus accounting for both domestic production and imports of plastic materials and products needed to support the megatrends listed above and regional differences in those trends.

To better understand the specific drivers of plastic demand growth, a detailed segmentation of demand for each polymer type is combined into 6 common demand segments: Packaging, Consumer Goods, Construction/Infrastructure, Textiles/Raffia/Nonwovens (excludes PET fiber), Transportation and all Other.

4.2 Global Trends and Forecast

Global plastics demand is expected to increase from 280 million metric tons (mmt) in 2018 to 437 mmt by 2030 representing an AAGR of 3.5%. This follows global growth of 6% from 1990 to 2000 and 4% from 2000 to 2018. Demand growth is expected to moderate to 2.1% from 2030 to 2050 yet still adding another 200 mmt of demand reaching 686 mmt by 2050.

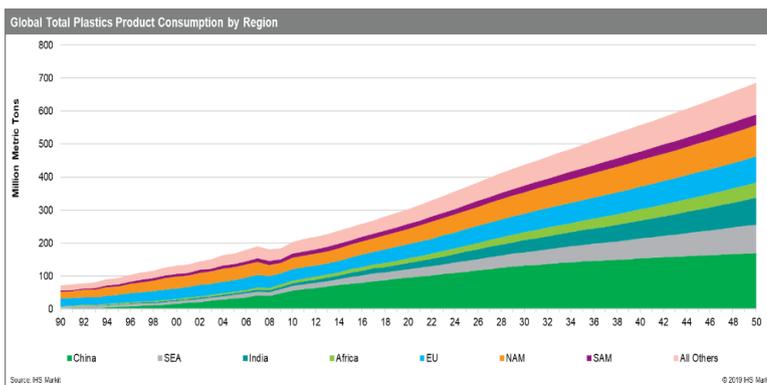
Early growth was supported by increasing per capita consumption in developed regions and continued replacement of alternative materials by plastics with increasing features providing functionality, safety and cost benefits.



Global per capita consumption growth will moderate as emerging countries approach per capita consumption of today’s developed regions impacted also by sustainability efforts.

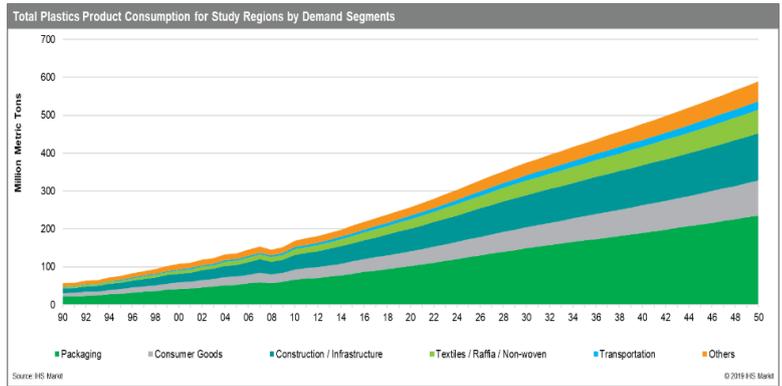
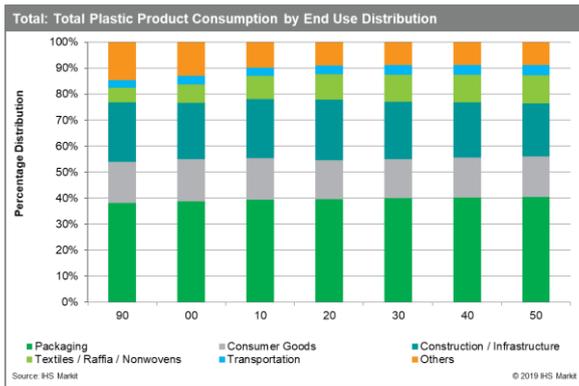
Polyolefins currently represent the largest product share globally at 67% in 2018 (PP 28%, HDPE 18% LLDPE 12% LDPE 8%), PVC is next at 17%, PET 10%, PS 4%, EPS 2%. Demand growth will result in an increasing share of polyolefins – from 67% 2018 to 74% 2050. PVC share declines from 17% to 13%, PS/EPS from 6 to 4%, PET from 10% to 9%

Despite the global demand slow down resulting from the 2008 financial crisis, growth continued to outpace overall GDP with global demand being fueled by especially high demand from China and its export-oriented industries.



China is the largest demand region at 31% of total demand currently (note domestic demand has been adjusted to reflect local use vs total domestic demand including converted product exports). During the forecast period demand becomes more globally distributed: China’s share declines to 28% by 2050 (driven by population decline and accelerated growth in other regions) while Southeast Asia increases from 8% to 13%, India grows from 6% to 12% and Africa grows from 4 to 7%.

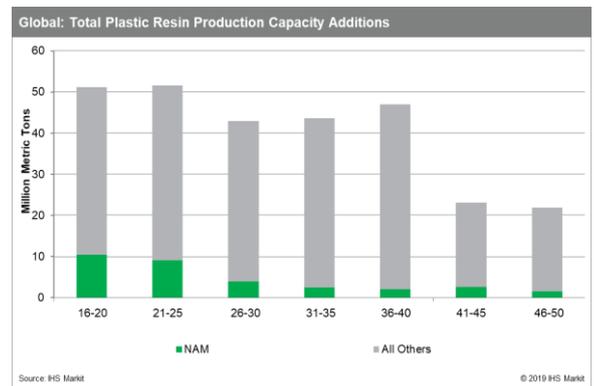
Packaging represents the largest demand segment. By the late 1990's packaging had risen to 40% of total plastics demand and is expected to remain at that level thru the forecast period.



The study segment share positions of total plastics are expected to remain steady during the forecast period with Consumer Goods at 15-16%, Construction & Infrastructure at 21-23%, Textiles / Raffia / Nonwovens at 10-11%, Transportation at 3-4% and Other at 9%.

The chart above shows the relative consistency of the segment shares over time from 1990 through 2050 with the share distribution in each year in increments of 10 years.

A significant amount of resin capacity will be needed in the future to meet the growing global demand. While there is significant new capacity planned for North America in the next 10 years, it is only a small portion of the total capacity needed and being planned for in other regions of the world. If not supplied from North America, future demand will be met by new capacity additions in other regions. Planned and expected capacity additions in each of the forecast 5-year periods are shown in the graph to the right.

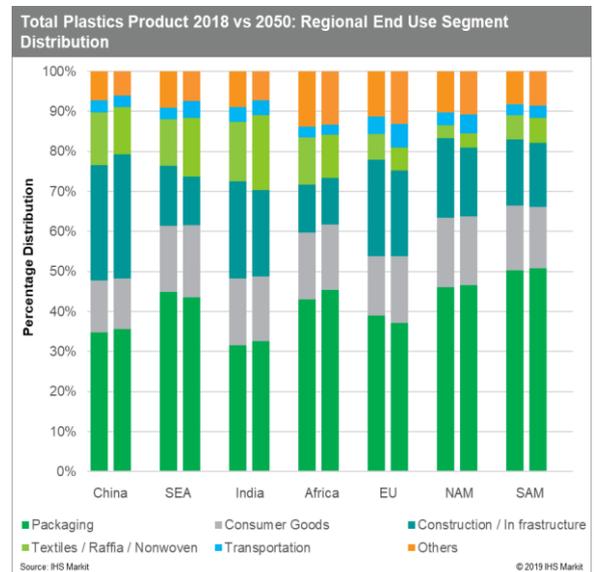


4.3 End Use Segments

Packaging

Packaging is ubiquitous, and all the major polymers contribute to meet growing global demand. Flexible packaging film and sheet accounts for a large proportion of polyolefins (PE and PP) demand but PET and PVC are also used in these applications. Rigid packaging manufactured in different molding processes – injection molding (small and large containers and products – food storage and distribution, auto parts, diagnostics, labware, toys, appliances, paint, chemicals), blow molding (small and large containers primarily for products in liquid form including water, consumer/industrial cleaning and bulk liquid foods), rotational molding (large hollow parts: industrial drums, water storage tanks) – are produced from all these base polymers.

Packaging is critical in protecting and extending the shelf-life of food, both solid and liquid, and preventing waste, especially as growing populations become more concentrated in urban settings, transport distances grow, and agriculture resources are strained. Packaging allows for consolidated sources of food processing thus



reducing the potential for contamination. Expansion of industries that provide commodity food (raw grain and commodity rice) as well as polymers themselves is driving growth of form-fill-seal-bags, a growing preference to raffia woven bags in some segments. (Packaging applications using raffia are covered in the textile / raffia / nonwovens section).

Packaging is a critical component in making proper healthcare available to all and preventing the spread of disease. Packaging allows for the controlled supply of critical elements of healthcare: blood storage, IV bags, sanitized devices and testing equipment.

Recent examples from China illustrate how increasing middle-class populations, with increased spending power, accompanied by the rapid migration rate of those searching for better living environments have driven changes in food consumption patterns. The fast development of online shopping is driving growth especially for LLDPE/LDPE film and sealing tape/strapping and the rapid growth of app-enabled food delivery/takeaways has dramatically increased the demand for plastics packaging.

PP used for bottles as well as plastic films for blister packs will continue to grow. Packaging of sterilized devices and labware will grow as healthcare services expand.

Packaging can be considered durable or non-durable depending on its usage and whether the package is disposed of after initial use (flexible packaging at retail) or reused (molded containers for bulk food/non-food commodities). The same holds for defining packaging as discretionary or non-discretionary depending on the product it contains. Many of the non-durable/discretionary products and packaging are visible at retail but there is an enormous number of both non-durable and durable applications that are essential to supporting the world's population.

Consumer Goods

Megatrends will drive increased plastics demand for a wide range of consumer products including small and large appliances and electronics components. Plastics are a key material of choice as structural components, insulation, consumer wire and cable for such products as computers and mobile communication devices. In addition to large and small appliances, demand for furniture and storage containers will drive plastics demand. Healthcare products are included in the consumers goods segmentation. Medical devices, drug delivery systems, blood storage, labware, and testing equipment are all produced using plastics. With an increasing middle-class, sports and leisure activities will drive demand for a wide range of plastics based products that provide function, impact resistance and weight reduction at affordable costs including sports equipment, protective gear as well as the supporting platforms and facilities; kayaks, helmets, sports courts, stadium seating just to list a few examples.

Construction/Infrastructure

Demand for plastics in infrastructure comprises both durable and non-durable applications. Urbanization brings an increasing need for significant pipe (and fittings) networks, particularly for HDPE and PVC. Flooring applications will drive demand particularly for PVC. The "toilet revolution" (toilet installation and improvement efforts) in developing regions, is expected to grow at a faster rate in the next five years, also impacting pipe demand. The growth of the building/construction sector in developing regions will drive the demand for plastics such as HDPE used for moisture barrier and EPS, the majority of which globally is used for insulation.

Another example is in China where the environmentally driven shift of commercial and residential energy supply from coal to gas-based significantly increased demand for pipe (HDPE, PVC) and a rapid growth of photovoltaic power generation drives increased demand for EVA specialty films.

The largest non-durable segment is in agriculture which benefits greatly from the use of plastic films to increase crop yields.

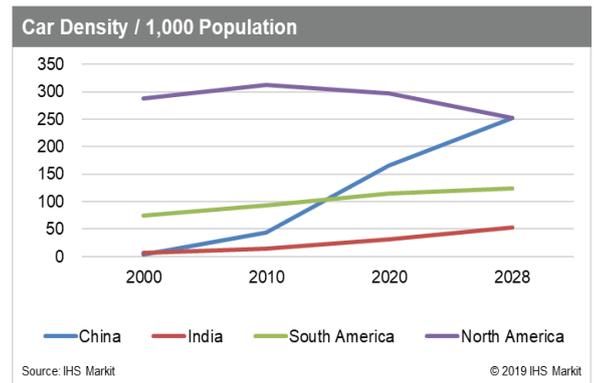
Textiles/Raffia/Nonwovens

Plastics-based fibers provides functionality and protection for society in applications such as protective vests and flame-retardant clothing and furnishings. Nonwoven plastics are the material of choice for surgical masks and gowns helping prevent infection. Plastics based fibers are used extensively in filtration systems of all kinds as well as in a range of industrial and consumer cleaning and absorptions applications such as wipes and diapers.

Developing regions are large consumers of woven bags (note: woven bags account for roughly a third of China’s current demand for PP) used in packaging of grains, polymers, fertilizers, cement and fodder thus allowing for broad distribution of base food commodities in regions lacking established bulk distribution systems.

Transportation

The increase in vehicles per person developed by IHS Markit’s “Insight into Mobility” (transition from internal combustion engines (ICE) to hybrid and electric vehicles (EV) drivetrains, car ownership models, ride sharing, etc.) helps translate the impact of megatrends into materials demand for transportation. For example, the graph to the right shows the change in number of vehicles per 1,000 people over time. While North America is now trending down, other less developed areas are showing significant growth.



Plastics are essential to transportation. Properties such as formability, impact and heat resistance and light weighting provide high performance at low cost and contribute to meeting CAFE (Corporate Average Fuel Economy) standards and reduced emissions. One good example is the replacement of traditional metal-based fuel tanks with molded, HDPE-based tanks. Other plastics, PP based compounds and engineering resins in particular, will continue to grow as they provide high value functionality and weight reduction at low cost in exterior, interior and under-the-hood applications.

5 Regional Analysis

The regions of North America, Europe and South America exhibit similar trends in that they have a relatively high urbanization level with demand for plastics correlated primarily to an increasing level of consumption spending on durable and non-durable goods. China is now going through a transition from high growth and increasing population to a period of more measured growth and a declining population. The high growth areas of Southeast Asia, India and Africa are expected to see large increases in population, increasing urbanization and a significant rise in living standards through a growing middle class and increased amount of consumption of durable and non-durable goods.

Regional Comparison of Economic Variables - change from 2020 to 2050														
	North America		Europe		South America		Southeast Asia		India		Africa		China	
	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050	2020	2050
Population (millions)	505	602	633	636	530	616	619	744	1,383	1,663	1,348	2,492	1,425	1,370
Middle Class (% of total households)	76%	71%	86%	86%	55%	69%	66%	83%	76%	89%	39%	41%	54%	78%
Urbanization (% of total population)	83%	88%	77%	85%	82%	88%	54%	67%	34%	49%	45%	57%	61%	77%
Consumption of durable and non-durable goods (thousands of constant 2015 USD per household)	\$27.3	\$48.3	\$17.5	\$25.2	\$7.5	\$13.8	\$6.1	\$13.8	\$2.7	\$9.4	\$3.8	\$5.1	\$5.3	\$17.5

Source: IHS Markit © 2019 IHS Markit

A slowdown in average annual growth rate for all commodities in all regions is seen when comparing 2018-2030 vs 2030-2050. In most regions and in both time frames, plastics demand is slightly higher than the growth rates for other materials. Steel and aluminum are generally lower with the other non-plastic materials growing at similar rates. High

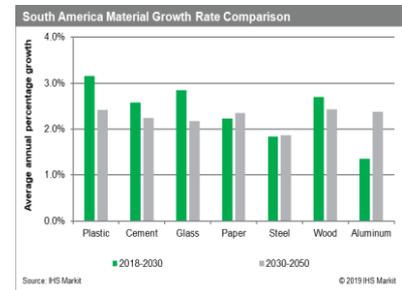
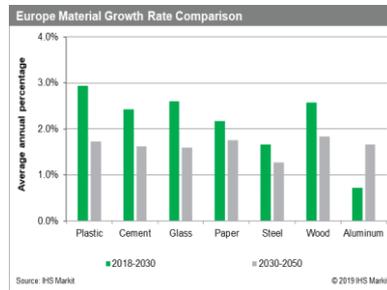
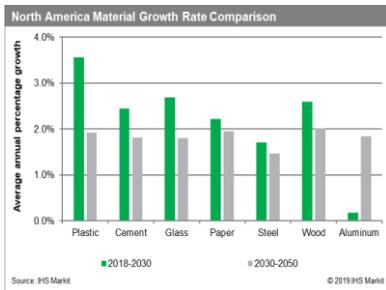
growth areas of Southeast Asia, India and Africa will continue to see growth rates for most commodity materials at or above 3% in the 2030 – 2050 time period while the other regions will be at or below 2% for all materials.

Regional Comparison of Commodity Demand Growth for 2018-2030 and 2030-2050														
	North America		Europe		South America		Southeast Asia		India		Africa		China	
	2018-30	2030-50	2018-30	2030-50	2018-30	2030-50	2018-30	2030-50	2018-30	2030-50	2018-30	2030-50	2018-30	2030-50
Plastic	3.6%	1.9%	2.9%	1.7%	3.2%	2.4%	4.7%	3.8%	6.8%	4.2%	5.7%	3.4%	3.9%	1.7%
Cement	2.5%	1.8%	2.4%	1.6%	2.6%	2.2%	3.4%	3.4%	4.5%	4.1%	3.3%	2.9%	3.9%	2.0%
Glass	2.7%	1.8%	2.6%	1.6%	2.9%	2.2%	3.4%	3.3%	4.8%	4.1%	3.3%	2.8%	4.1%	2.0%
Paper	2.2%	2.0%	2.2%	1.8%	2.2%	2.3%	3.1%	3.6%	4.3%	4.2%	2.9%	3.0%	3.7%	2.2%
Steel	1.7%	1.5%	1.7%	1.3%	1.8%	1.9%	2.7%	3.1%	3.7%	3.7%	2.5%	2.5%	3.1%	1.6%
Wood	2.6%	2.0%	2.6%	1.8%	2.7%	2.4%	3.3%	3.6%	4.7%	4.3%	3.2%	3.0%	4.0%	2.3%
Aluminum	0.2%	1.8%	0.7%	1.7%	1.4%	2.4%	2.7%	3.9%	3.2%	4.3%	2.3%	3.4%	2.2%	1.3%

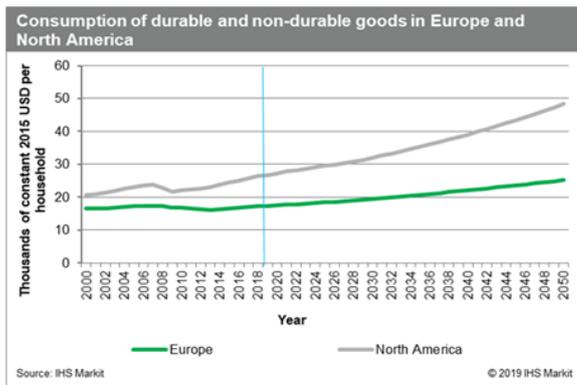
Source: IHS Markit © 2019 IHS Markit

5.1 Moderate Growth – North America, Europe, South America

Demand for plastics as well as other commodity materials in North America, Europe and South America show a similar projected growth relative to other commodity materials with a declining rate in 2030 – 2050.



The key drivers of demand growth in all 3 regions is the expected increase in household consumption expenditures as well as a growing share of middle class households in South America.

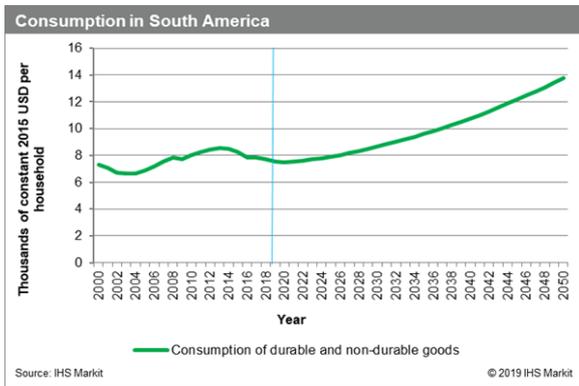


Consumption of durable and non-durable goods per household in North America declined during the Great Recession but started to rise again in 2010 reaching approximately \$26,500 in 2018. The forecast for consumption of durable and non-durable goods per household will rise, at a slightly increasing rate to about \$48,000 in 2050 driven by higher real incomes per household.

Consumption of durable and non-durable goods in Europe has increased slightly from 2000 levels. In terms of constant 2015 USD, the average household consumed \$16,470 in 2000. Between 2007 and 2014, consumption of durable and non-durable goods per household started to decline caused by the Great Recession and the

European debt crisis in 2010. The European debt crisis has had a profound impact on the European economy. Banks in the euro area were left with a large stock of nonperforming loans, which held back lending, suppressed investment, and thus dragged down overall consumption. Consumption of durable and non-durable goods started recovering after 2014 and has reached \$17,261 constant 2015 USD in 2018. In the next ten years, we forecast consumption to rise to \$19,272 constant 2015 USD at a compound annual growth rate of 1.0%. By 2050, consumption of durable and non-durable goods is expected to reach \$25,154 constant 2015 USD per household on average.

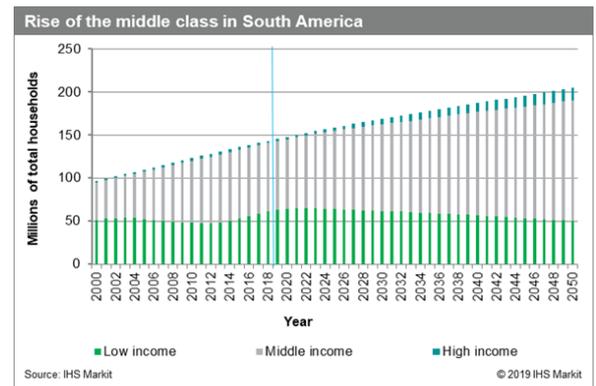
Since the United States, which accounts for a big portion of North America’s consumption spending, is more consumption-driven than its European peers, consumption spending in North America is projected to grow faster than in Europe.



South American consumption of durable and non-durable goods has varied from 2000 to 2018. In 2000, in terms of constant 2015 USD, consumption of an average household was \$7,286. Although suffering a slight drop during the Great Recession in 2008, consumption of durable and non-durable goods rose to \$8,427 constant 2015 USD by 2012. After 2012, consumption began falling in the South America region due to dropping commodity prices and the worsening economic climate. In 2018, consumption of durable and non-durable per average household goods hit \$7,698 constant 2015 USD. We forecast that by 2020 consumption per household will hit its lowest point, then rise through the rest of the forecast period. By 2050, we forecast the average household in South

America will spend \$13,757 constant 2015 USD on consumption of durable and non-durable goods.

In addition to consumption spending, the rise of the middle class in South America has a significant impact on the forecasted demand for plastics and other commodity materials. Up until about 2013, the percentage of middle class households increased and reached around 60% of total households. However, after 2013, there was a slight decline in the percentage of middle class households as the percentage of low-income households rose. According to a report by the IMF titled “Northern Spring, Southern Chills,” the downturn in global commodity markets, and country-specific factors like waning confidence in Brazil’s private sector, worsened the economic situations in many South American countries. In 2018, middle class households represented 56% of all households. We forecast that this percentage of middle class households will suffer more decline over the next few years and then start to increase once again around 2021. Beyond 2021, the percentage of middle class households will steadily increase through 2050. By 2050, we predict that the percentage of middle-income households in South America will be approximately 69%.

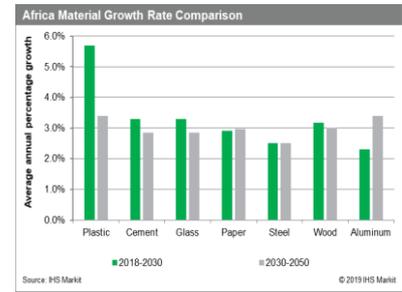
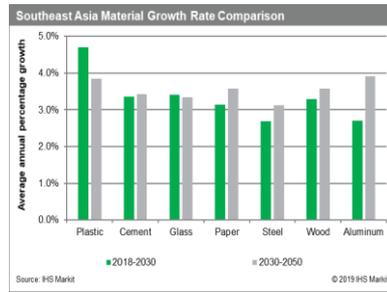
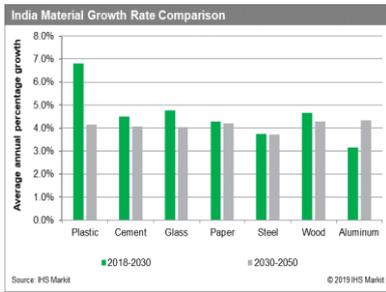


In North America, the share of households in the middle class peaked at just under 80% in the early 2000s, and since then has begun a gradual, long-term decline to a share of 70% expected in 2050. The shares of high income and low-income households were about equal at 12% in 2018 as the share of low-income households fell noticeably during the recovery from the Great Recession. In the future, the primary reason for the gradual decline in the share of middle income households will be the increase in the share of high-income households – i.e. middle-income households moving into the high-income category. In Europe, the middle class has consistently represented 83% to 86% of the total households. This is a result of their stable economic growth rates and political systems. We forecast the same level of stability to continue through 2050 and therefore will not have a significant impact on the demand for plastics and other materials.

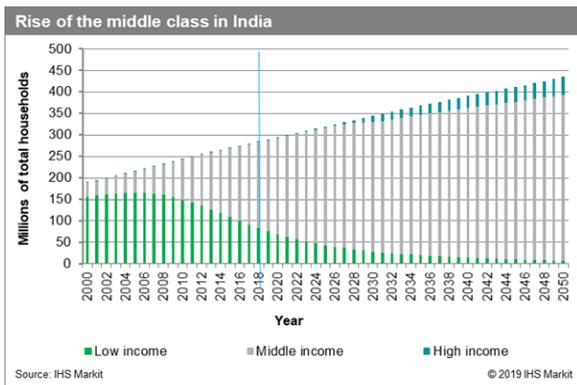
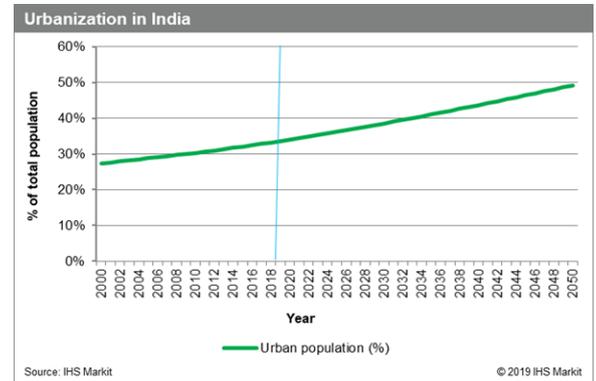
The percent of each region’s population living in an urban setting in 2000 was already at a high-level ranging from 72% in Europe, 77% in South America and 79% in North America. All regions are expected to see a continued slow growth in urbanization each reaching 86% – 88% by the year 2050. The stability in urbanization results in it not having a significant impact on the demand for plastics and other materials during the forecast period.

5.2 High Growth – India, Southeast Asia, Africa

Demand for plastics as well as other commodity materials in India, Southeast Asia and Africa will grow at a faster pace than other regions. While starting from a smaller base compared to other regions, plastics are expected to grow around 5% – 6% vs 3.5% – 4% for other materials during the next 10 years. From 2030 to 2050, the growth rates are expected to slow with plastics still growing ahead of the other commodity materials. Each region is affected differently by the megatrends considered for this report as discussed below.

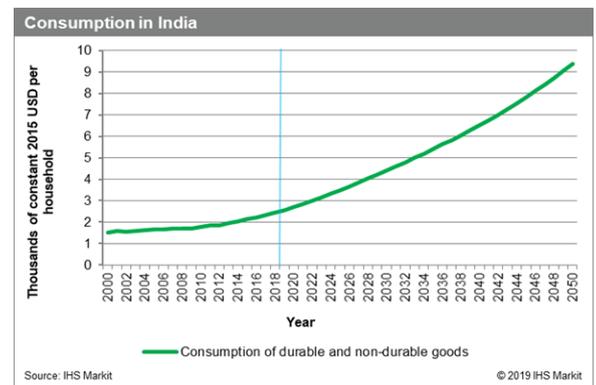


Urbanization in India has been on a steady incline since 2000. At the beginning of the millennium, about 27% of people (288 million people) lived in urban areas. In 2018, the proportion of people in urban areas grew to 33% (450 million people). In the next five years we forecast the percentage of people classified as living in urban areas to increase to 500 million people. The growth of urbanization is forecasted to continue at a steady rate in the future, reaching 49% of the population (more than 800 million people) living in urban areas by 2050.



In India, the percentage of households in the middle class increased from about 17% (32 million households) in 2000 to over 70% (200 million households) in 2018, a compound growth rate of 11% per year in the eighteen-year period of the number of households in the middle class. The rapid increase of the middle class in India is expected to continue through around 2028. In the future, the percentage of middle class household in India will plateau as the percentage of high-income households increases and the percentage of low-income households decreases. By 2050, the percentage of middle class households will reach 89%.

Consumption of durable and non-durable goods in India experienced slow growth between 2000 and 2018, with slightly faster growth beginning in 2012. The average household in 2000 spent \$1,500 constant 2015 USD and by 2018 consumption increased to \$2,400 constant 2015 USD. In the future, we forecast rapid growth of consumption of durable and non-durable goods in India. Between 2019 and 2023, average household consumption is expected to rise from \$2,600 constant 2015 USD to \$3,000 constant 2015 USD. Growth will continue at a rapid pace after 2023 through 2050. A main cause of the increase in consumption is the rise of the middle class. As more households enter the middle class, the greater their disposable income becomes and the greater the demand for durable and non-durable goods.



Our modeling of the drivers of historical demand for plastic showed that urbanization and consumption of durable and non-durable goods in India were the most significant economic variables. As more people move to cities, there is an increasing demand for plastic and its end uses. To adjust to population expansion, urban areas must construct new

structures for residential and non-residential uses. Movement into urban areas is also related to rising real income. More income gives people greater mobility to move to cities and other urban areas. Rising real income is also associated with an increase in consumer spending. When a household's real income increases, it has more money to spend on consumer goods, like plastic products or products with plastic packaging.

Southeast Asia is steadily undergoing urbanization. In 2018, an estimated 53% of Southeast Asia's total population lived in urban areas, compared to 42% in 2000. In the next ten years, the compound annual growth rate of percentage of people living in urban areas is forecasted to be 0.9%, with the percentage of urban population increasing to about 59% in 2029. In the future, we forecast the percentage of total population in Southeast Asia living in an urban area will rise but at a slower pace. Spending on durable and non-durable goods in Southeast Asia was slowly increasing from 2000 up until 2018 at a compound annual growth rate of 1.7%. From 2019 to 2050, we forecast that there will be a steady increase in average household consumption.

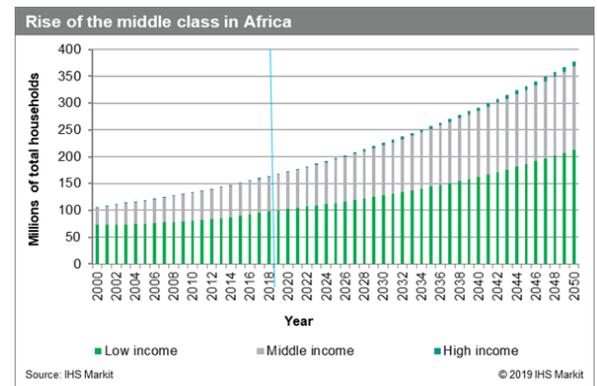
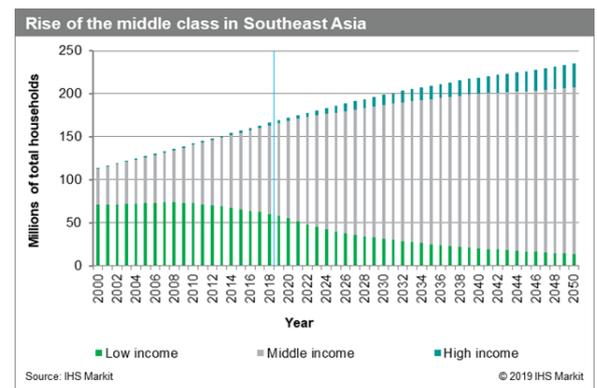
The middle-class population in Southeast Asia has been rapidly growing since 2000. Through 2018, the middle class grew from around 35% to over 60% of the region's total households. In the past nineteen years, approximately 52 million households in Southeast Asia entered the middle-class. Prior to 2010, the lower income households held the majority in Southeast Asia. We expect the percent of middle class households to hit 80% around 2032. From then on, the growth of the middle class will still be positive but will be moving at a slower rate.

From the economic variables considered in this report, the rise of the middle class showed the strongest correlation with plastic demand in Southeast Asia.

The rise of the middle class has been slow in Africa since 2000. From 2000 to 2018, the percentage of middle class households in Africa increased from about 31% to about 39%. In the future, we expect the percentage of middle class households in Africa to remain steady and increase only slightly each year through 2050. The small change is caused by the total number of households growing at a faster pace than the number of middle class households. The pace of household growth in history and forecast is caused primarily by better medical care, which has lowered infant and child mortality rates and increased the average life expectancy in the region. The number of middle class households is rising at slower rates each year due lack of jobs. The African Development Bank estimates that to employ all the young people entering the workforce, over 10 million jobs must be created each year.

The percentage of Africa's total population located in urban areas has been steadily rising since 2000. About 37% of the population was considered urban in 2000 and then rose to 44% of the population in 2018. In the next ten years, we forecast that the percentage of Africa's total population residing in urban areas will increase at a compound growth rate of about 0.8% a year, a slightly slower rate than the previous nineteen years. Between 2019 and 2029, we forecast the percentage of urban population to grow from 44% to 48%. The rise of urbanization will continue through 2050.

In Africa, consumption of durable and non-durable goods per household rose from \$2,500 constant 2015 USD in 2000 to \$3,700 constant 2015 USD in 2018, a compound annual growth rate of 2.0%. However, the rise of consumption has not been smooth and suffered several drops in the last nineteen years, most notably starting in 2004 and 2009 due to the

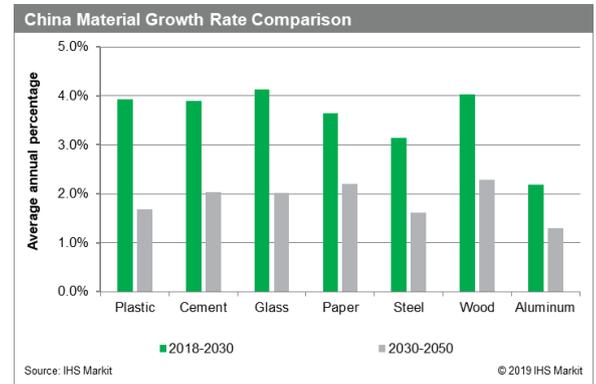


region’s relative bigger exposure to political risks, external shocks, as well as natural disasters. In the future, we forecast steady growth in consumption of durable and non-durable good per household through the end of 2050.

From the economic variables urbanization showed the strongest correlation with plastic demand in Africa.

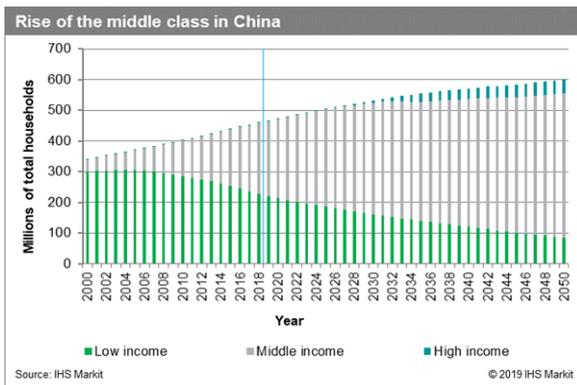
5.3 Transitioning Growth – China

China’s economy is undergoing a major shift. The policies of the past 30 years that emphasized high growth of more than 10% per year have shifted to policies targeting more measured growth rates. The Chinese government aims for more sustainable growth that will provide its nation with stable employment. The government has shifted its focus to growing domestic consumption, with lower reliance on export-oriented manufacturing. These new policies also include cutting back on excess-capacity products, increasing the quality of life through quicker urbanization, and emphasizing environmental protection and anticorruption efforts. While these new policies have served to decelerate growth, the overall economy seems to be adjusting quite smoothly. China’s plastics demand growth continues to stay resilient even with a decelerated GDP growth rate.



Through comparison of average annual growth rates for selected commodities, wood and glass show the highest growth rates in demand in both the near-term time period as well as for 2030 – 2050. Aluminum has the slowest growth in demand.

The annual population growth rate in China has been declining since 2000. In 2000, the population grew 0.6% from the previous year, declining gradually to 0.4% annual growth by 2018. The forecasted growth rate will continue a steady decline through the next ten years until eventually reaching zero growth around 2029. Thereafter China’s total population in absolute terms will decline steadily through 2050.

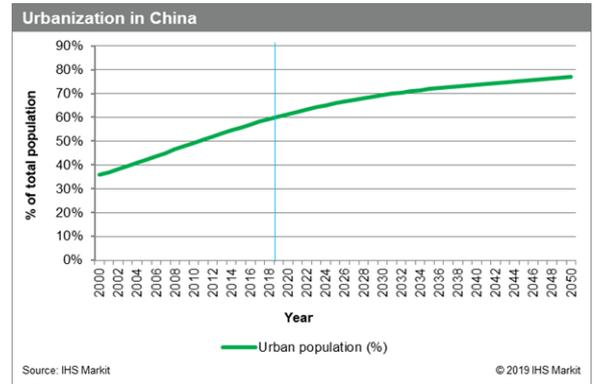


The middle class in China has experienced rapid growth since the beginning of the century. In just 18 years, the percentage of its total households defined as being middle class has increased from 11.5% in 2000 to 50.2% in 2018. Approximately 191 million households in China moved to the middle class in this nineteen-year period. Most Chinese households prior to 2018 were categorized as low-income households. As time went on, the middle class continued to grow, and the lower class shrank so that by 2018 the number of middle class households was higher than the number of low-income households. In the next five years, the trend of growth of the middle class is expected to continue so that by 2029 over two-thirds of China’s households will be considered middle class. Thereafter, the

size of the middle class will continue to grow but at a slower rate.

There will be a continuing rise of the middle class with a growing number of households also moving into the high-income category. This increasing driver of demand will be offset only slightly by an overall population that will begin to decline during the forecast period.

The movement from rural areas to cities has been a trend in China in the past decades. In 2000, about one-third of the total population, approximately 459 million people, lived in urban areas. In 2018, those figures had risen to 59%, or 839 million people. In the next ten years, the compound annual growth rate of the proportion of urban population is forecast to be 1.4%. According a report by the Chinese Academy of Social Sciences, skilled workers, innovations, and industries will continue to spread from tier-one cities, like Beijing and Shanghai, to lower-tier cities supporting China's continuing development over the next 15 years. After 2030, the urban population in China will continue to grow, but at a slower pace than the beginning of the millennium.

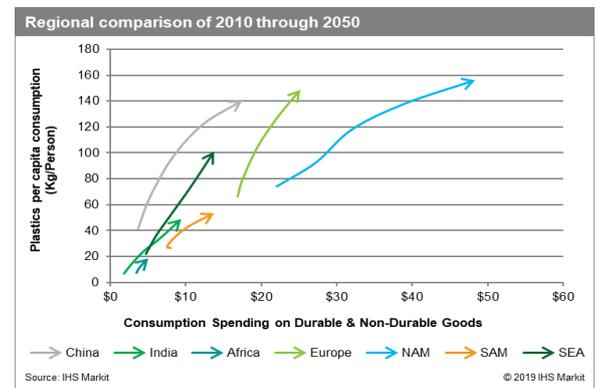


6 Conclusions

- The global trends of a growing population, an increasing middle class and movement of people from rural to an urban setting will cause a significant increase in demand for many of the products and conveniences some people take for granted today.
- While plastic waste is an acknowledged critical issue, the value of plastic has been well documented as a way of reducing the amount of material to achieve the same function as well as providing overall environmental benefits when considering life cycle analysis and taking into account energy demand, water consumption, solid waste, global warming potential, acidification potential, eutrophication potential, smog formation potential, and ozone depletion potential.
- To support a growing population and the drive to improve their standard of living, the global demand for plastic and other commodity materials such as wood, cement, glass and paper are expected to grow at an average annual rate of ~3.5% from 2018 – 2030 and then drop to ~2% for 2030 - 2050.
- Packaging represents the largest demand segment. By the 1990's packaging had risen to ~40% of total plastics demand and is expected to remain at that level through the forecast period. The study segment share positions of total plastics are expected to remain steady during the forecast period with Consumer Goods at 15-16%, Construction & Infrastructure at 21-23%, Textiles / Raffia / Nonwovens at 10-11%, Transportation at 3-4% and Other at 9%.
- China is the largest demand region at 31% of total demand currently. During the forecast period demand becomes more globally distributed: China's share declines to 28% by 2050 while Southeast Asia increases from 8% to 13%, India grows from 6% to 12% and Africa grows from 4 to 7%.
- A key driver of the growth of plastic in the future will be the increasing number of households moving from a low income to middle income category especially in developing regions like China, India, Southeast Asia and Africa. As a household's income increases, there is a greater amount of consumption of durable and non-durable goods which drives the demand for plastic in a variety of end use segments.
- Moderate growth areas are North America, Europe and South America where population growth and urbanization have reached higher levels and are expected to increase only slightly through 2050. The main driver of plastic and other material consumption in these areas is increased consumer spending especially in South America after recovering from the current economic difficulties which is expected around 2020. In these regions, plastics demand growth is expected to be in line with other commodity material demand growth.
- High growth areas are India, Southeast Asia and Africa where a large increase in population represented by an increasing number of households will be moving out of poverty and into an urban setting and life style while

significantly increasing their consumption spending. In these regions, the increasing demand for plastic and per capita consumption will be driven by the need for basic products and conveniences to improve their standard of living such as healthful packaged food, infrastructure development including roads and buildings, electricity distribution, sewer and water supply, gas distribution for cooking and heating and also energy efficient automobiles/transportation, housing and appliances. Plastics demand is expected to exceed the increased demand for other materials as the value in use benefits are recognized and follow the earlier trends in developed regions.

- China is transitioning from historical high growth to more measured growth with stable employment focusing on growing domestic consumption with lower reliance on export-oriented manufacturing. Urbanization is the strongest megatrend link to plastics demand growth in China. The migration of rural living to an urban environment results in plastics materials being needed for a variety of applications such as home appliances, automobiles, electrical and electronics products. In addition, the increasing number of people residing in urban settings require a greater amount of food transported from farm to urban areas with reduced spoilage and infrastructure development including electricity distribution, sewer and water supply, gas distribution for cooking and heating, roads and buildings, etc. China's per capita consumption growth in plastic begins to slow around 2030 as it reaches levels close to developed regions.
- Early growth of plastic was supported by increasing per capita consumption in developed regions and continued replacement of alternative materials by providing advantages in functionality, safety and cost benefits. Regional and overall global per capita consumption growth will moderate as emerging countries approach per capita consumption of today's developed regions and will also be increasingly impacted by sustainability efforts.



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