SECTION 2

Megatrends: From COVID-19 to Space and Beyond

SECTION 2.1
MEGATRENDS IN POPULATION, MIGRATION, POVERTY, AND INEQUALITY

The demographic profile of the world has changed tremendously over the past three decades, as total fertility has declined and as life expectancy has risen. Migration, both internal and international, has also expanded due to labor shortages, whether in highly-developed urban areas or in advanced countries, and, more broadly, as a response to existing inequalities in incomes and economic opportunities across places.

Population growth and migration movement are two factors that have impacted global and regional poverty and inequality changes in the last three decades. Poverty has declined over this period, but it has declined unevenly across different regions of the world. Inequality has dropped across some countries but has risen within many others. Moving forward and over the long term, climate change, technological development, and the current COVID-19 crisis are expected to impact the movement of people, the distribution of populations, and the evolution of poverty and economic inequality. The country's capacity to harness science, technology, and innovation (STI) is key to turning these trends into opportunities for rapid, sustainable, and inclusive socioeconomic development.

Population

World population growth has been positive, but declining, over the past few decades. World population grew at 2% per year from 1960 to 1970 (1960s), at 1.9% in the 1970s, 1.8% in the 1980s, 1.5% in the 1990s, and 1.2% in the 2000s and 2010s (UN DESA 2019).

Declining fertility rates (from 5.0 in 1960-65 to 2.5 in 2015-20) and longer life expectancy means population growth has varied widely across age groups. Annual average population growth for those 65 years and above actually rose from 2.6% in the 1960s to 3.2% in the 2010s. In contrast, annual average population growth for those in the 15-64 age group (working age) declined from 1.8% to 1.1% in the same period, while growth of those 14 years and below dropped even steeper from 2.1% to 0.6%.

Population growth varied widely across different regions of the world. In Sub-Saharan Africa, the population grew at 2.7% per year from 1990 to 2020, but in the Philippines and the rest of East Asia and the Pacific, the population only grew at 0.9% per year. East Asia and the Pacific are rapidly aging, as the population of those 65 years and older grew at 3.2% annually in the past three decades, while the population of those in the 15-64 age group grew 1.1%, and those 14 years and below actually declined by -0.6% per year. As a consequence, in the same period, the share of those aged 14 years and below in the total population declined from 29.7% to 19.6%, while the share of those 65 years and older almost doubled from 5.7% to 11.2%. Within East Asia and the Pacific, declining population growth and increased ageing were particularly sharp in the more developed countries of the region, such as Japan, Korea, and Taiwan.

For many developing Asian countries, the rapid decline in population growth over the past three decades has meant a decline in the dependency ratio (ratio of 15-64 population to sum of 0-14 population and 65+ population), which has contributed positively to their rapid economic development. This growth in the economy attributed to changes in the age structure of the population has been termed the "demographic dividend." Some studies have estimated that about one-third of the economic growth achieved by the tiger economies of East Asia from 1965 to 1995 were from the demographic dividend (Bloom and Canning 2001; Bloom and Williamson 1997; Radelet et al. 1997, as cited in Mapa 2015).

The countries in the best positions to avail of the demographic dividend are those where the working-age population have quality education and good health, and where there are sufficient quality jobs to absorb them (UNFPA 2016). The Philippines has yet to benefit fully from the demographic dividend because of the slow decline in its fertility rate (Mapa and Balisacan 2004). For more advanced countries, however, the extended decline in population growth has led to the ageing of the population and, in some cases, labor shortages that have posed or are posing a threat to further economic growth, absent adjustments such as large-scale automation, economic restructuring, or migrant worker inflow (Ducanes and Abella 2008).

In the next three decades, these demographic shifts will continue to have an impact on economic growth and well-being, especially as developing countries, including the Philippines, transition to higher income status. The expected shift of manufacturing to greater automation, and the pressure that change will exert on lower-skill work, poses a particular challenge to countries that have yet to benefit from the demographic dividend.

The world population was estimated at 7.9 billion in 2020, and it is projected to grow to 9.7 billion by 2050, with half of the population growth coming from Sub-Saharan Africa. In Southeast Asia, specifically, the total population is expected to grow from 669 million in 2020, to 794 million in 2050, with the population expected to rise in all countries except for Thailand.

Climate change is projected to have a huge impact on the distribution of the population within and, even, across countries. A World Bank (WB) report focusing on Sub-Saharan Africa, South Asia, and Latin America, projects more than 143 million migrating internally by 2050 due to climate change (Rigaud et al. 2018).

A study by the European Commission, meanwhile, projects climate change can drive anywhere from 25 million to one billion people into internal or external migration by 2050 (Artuso and Guijt 2020). This includes people moving away from lower water availability and crop productivity, and coastal areas with rising sea levels and storm surges. This projection may be especially important for the Philippines, which is visited by an average of 20 typhoons per year and has experienced five of the strongest tropical cyclones in history—four of which were experienced just in the last 10 years (Masters 2020).

Migration

Globally, the number of external or international migrants was estimated at 272 million in 2019, equivalent to about 3.5% of the global population; this is up from 2.8% in 2000 and 2.3% in 1980 (UN 2020). Of the total international migrants in 2019, some 84 million are in Asia, 82 million in Europe, 59 million in North America, and 27 million in Africa. About 60% of these migrants moved for work reasons. The still-large income differential between most origin and destination countries, the better standards of living in many destination countries, robust migrant networks, labor shortages in some developed but ageing countries, and the declining cost of travel have contributed to the high—and still burgeoning—level of global migration.

About 40% of all international immigrants in 2019 came from Asia, and about half of these Asian migrants moved to other Asian countries (IOM 2019). In absolute numbers, the Asian countries with the largest number of migrants abroad are India and China, but a large number of Asian immigrants also came from Bangladesh, the Syrian Arab Republic, Pakistan, the Philippines, Afghanistan, and Indonesia.

Pre-COVID-19, international migration was expected to continue to grow across Asia and the rest of the world given demographic pressures, more open borders and greater ease of travel, and the existing disparities in income and economic opportunities across countries. However, the pandemic has resulted in travel restrictions and other constraints that halted migration in many existing corridors. In fact, the crisis could potentially result in the displacement and return of millions of migrant workers to their countries of origin (ILO 2020).

For the Philippines, which has depended on foreign remittances since the 1980s, the latest reports as of November 2020 show that over 250,000 overseas Filipino workers were repatriated since the onset of the pandemic (DFA 2020), affecting not just household incomes, but also economic mobility.

Indeed, for as long as the COVID-19 threat is present, international migration is unlikely to pick up. Further, the longer-term effects of the pandemic on international migration remains uncertain.

Poverty

Global and regional poverty have rapidly declined over the past three decades. Global extreme poverty (based on Purchasing Power Parity $1.90-a-day poverty line) declined to 10% in 2015—the latest year for which data is available—from 36% in 1990 (World Bank 2020b). The reduction in poverty cuts across all regions of the world, but very unevenly.

Extreme poverty in East Asia and the Pacific experienced a steep drop from 61% in 1990 to only 2% in 2015, and further, to just one percent in 2018. In the Sub-Saharan Africa region, in contrast, extreme poverty declined only slowly to 42% in 2015 from 55% in 1990.

Sustained economic growth in many developing countries, particularly in Asia, is credited with a large role in global poverty reduction (World Bank 2016). In East Asia and the Pacific, China drove most of the poverty reduction, with a rapidly industrializing economy that grew by 10% annually, and created millions of jobs every year. The jobs benefited not only urban workers, but also rural workers and their households, via internal migration. Extreme poverty in China dropped from 66% in 1990 to only half a percent by 2016.

People with lower education, who live in rural areas, work on farms, and are part of big households are still over-represented among the poor (Dugarova and Gulasan 2017; World Bank 2020b). Despite rapid urbanization in most developing countries, poverty is still predominantly a rural phenomenon, accounting for nearly two-thirds of total national poverty.

In the Philippines, poverty reduction in the three decades preceding the COVID-19 pandemic was slow compared to the rest of East Asia and the Pacific—particularly Indonesia, Thailand, and Vietnam. The proximate reasons for this low rate of poverty reduction were the country's comparatively slower economic growth, high population growth, and high inequality in the distribution of incomes and opportunities. Indeed, what was peculiar in the Philippine case was the country's relatively weak response of poverty reduction to economic growth, even after controlling for the level of economic growth (Balisacan 2019).

Prior to the COVID-19 crisis, it was estimated that global extreme poverty could be halved and, possibly, eliminated by 2030, if developing countries maintained recent per capita income growth and the growth was shared broadly across the population (Granoff et al. 2015).

But with the COVID-19 crisis, an additional 110 to 150 million people worldwide could be pushed into extreme poverty in 2020 and 2021, which

will raise extreme poverty incidence by as many as four percentage points by 2030, compared to the no-pandemic scenario (World Bank 2020b). In East Asia and the Pacific, extreme poverty is projected to increase by 5 million to 9 million people in 2020.

Separately, the World Bank (2020b) estimates that climate change could potentially raise global extreme poverty by 68 to 132 million people by 2030, depending on the scope and severity of the climate-change impacts.

The channels through which climate change are expected to impact poverty are agricultural productivity, food prices, natural hazards, the effect of extreme temperature on outdoor workers' productivity, and health issues (World Bank 2020b). Some forecasts are even bleaker, such as the Overseas Development Institute's forecast of 720 million more poor between 2030 and 2050 because of climate change (Granoff et al. 2015).

Moving forward, it is expected that there will be greater focus on multidimensional poverty, which looks not only at income poverty but also at lack of access to education (attainment and enrollment), health (longevity), and basic infrastructure (electricity, connectivity, sanitation and drinking water). Here as well, progress has been uneven across countries and across dimensions.

According to the World Bank (2020b), circa 2017, the multi-dimensional poverty headcount ratio was at 14%, and deprivation was relatively still high in sanitation and educational attainment, especially for Sub-Saharan Africa and South Asia. East Asia and the Pacific scored poorly relative to other regions (except Sub-Saharan Africa), in access to safe drinking water.

Economic Inequality

Some caveats on availability and quality of data limit the precise measurement of income and wealth inequality, and how they have moved over time. But some studies find that income inequality has significantly declined among countries but risen within countries in the past 25 to 30 years (Bourguignon 2017; Milanovic 2018).

The decline in inequality among countries has been attributed to rapid economic growth in some developing countries with very large populations, especially China and India, and their rapidly expanding middle classes (Milanovic 2018).

Meanwhile, income inequality within-country was found to have increased compared to a quarter of a century before in the majority of developed countries and some of the largest developing countries, in particular, again, China and India, but also Indonesia (Bourguignon 2017).

Atkinson et al. (2011), using historical income tax data, found that the income share of the top one percent in many developed countries has substantially

gone up over the previous three decades. Dugarova and Gulasan (2017) further argue that if the rise in inequality within-countries continues, it could possibly raise global inequality again.

The factors that have been identified to have exerted significant upward pressure on inequality are tax policies that favored the rich, globalization, and skill-biased technology that disproportionately benefited those with higher skills, and those who had higher income or wealth in the first place (Alvaredo et al. 2013; Bourguignon 2017; Milanovic 2018; World Bank 2020b).

On the other hand, where inequality has declined, the factors that were found to have contributed to the decrease were public transfers, progressive taxation, and minimum wage policies (Dugarova and Gulasan 2017). The quality of economic growth has been found to matter as well, i.e., whether it creates many jobs or not, and who have access to those jobs, in determining the impact of economic growth on inequality.

The COVID-19 crisis could exacerbate income inequality, as it pushes firms to rapidly automate to minimize risks and reduce demand for low-skill and typically lower-income workers (Stiglitz 2020). Given that the pandemic has forced schools to shift to remote learning, which disadvantages students with poor digital access, or who go to schools which are ill-equipped for such a shift, and whose parents lack the education or skills to provide home learning—all likely to be students from low-income households to begin with, its impact can be long-term and even intergenerational.

On the one hand, the digital economy has been a growth accelerator for smaller businesses. On the other hand, it may increase inequality should essential digital platforms further weaken workers' bargaining power. As evidence indicates, rising inequality can disrupt social cohesion and breed socially unproductive rent-seeking activities. This disruption and economic waste tend to undermine the sustainability of economic growth.

Governments have tools at their disposal to tame inequality, moving forward. Granoff et al. (2015) sum up the key areas for interventions:

(a) boosting the human capital of the poor

(b) allowing the poor to accumulate assets

(c) improving pro-poor infrastructure and services

(d) increasing employment opportunities for the poor

(e) enhancing governance and political representation

Milanovic (2018), meanwhile, has made the case that global inequality (and poverty) can be further reduced via a more open labor migration policy.

Science, Technology, and Innovation as Enabler

STI play a key role in addressing the various dimensions of poverty and the highly inequitable distribution of opportunities in the Philippines. If harnessed well, STI can open up economic opportunities for the rapidly growing labor force, improve population mobility and human capital especially for the less well-off families, and mitigate and prevent the adverse effects of climate change, and advance institutions and governance toward shared prosperity.

Specifically, STI can make food and health systems more efficient, sustainable, and accessible to all, particularly the poor. It is key to solving the current health crisis and preventing future ones. Cleaner and more sustainable energy, water, and transport technologies will also enhance conservation efforts and prevent further environmental degradation. STI will also create more adaptable shelters, transportation systems, and other physical and digital infrastructure, which will not only protect vulnerable populations, but will also make the economy more resilient to future natural hazards.

Realizing the potentials of STI as an enabler of the economy and of society demands the government's strong commitment to mainstream STI effectively in the nation's vision, plans, and policy implementation for long-term growth and development (see also Section 3).

SECTION 2.2
CLIMATE CHANGE AND EXPLOITATION OF NATURAL RESOURCES: POLLUTION, GLOBAL WARMING, AND INCREASE IN EXTREME WEATHER EVENTS

Nature is vital to the achievement of the interconnected Sustainable Development Goals (SDGs) related to poverty, hunger, health, water, cities, climate, oceans, and land (SDGs 1, 2, 3, 6, 11, 13, 14, and 15). However, the current negative trends in biodiversity and ecosystems will most likely derail the progress towards achieving 80% of targets of SDGs (UNCCD 2017).

Planetary scale challenges came to the fore in the last couple of decades. There is an increasing realization among scientists and policymakers that the current trajectory of "development" is unsustainable. While rising gross domestic products (GDPs) are being recorded in many countries, natural ecosystems are being modified and natural resources are being depleted at unprecedented rates. This is manifested in worsening air quality and increasing air temperatures in most countries of the world, including the Philippines. Poor air quality is common in many large urban areas and air temperatures have been on upward trend for the last few decades.

Air Pollution

One of the negative impacts of economic development and urbanization is increasing air pollution. As might be expected, Metro Manila is the most polluted area in the Philippines. Based on a national emissions inventory conducted by the Environmental Management Bureau (EMB) in 2015, the majority (65%) of air pollutants in the country originated from mobile sources, such as vehicles. About 21% and 14%, were from stationary sources (e.g., power plants) and area sources (e.g., open burning of solid wastes), respectively, about 88% of air pollutants are from mobile sources with 10% from stationary sources and 2% from area sources. The major pollutants from mobile sources are volatile organic compounds and carbon monoxide, gases such as sulfur oxides and nitrogen oxides from stationary sources, and particulate matter from area sources (DENR-EMB 2019).

The main piece of legislation addressing air pollution is RA 8749, or the Clean Air Act. In compliance with the law, the EMB has implemented the following:

- Designation of airsheds throughout the country.
- Establishment and operationalization of the Air Quality Management Fund.
- Establishment of Ambient Air Quality Monitoring Network nationwide.
- Emissions inventory every three years.
- Management of mobile and stationary sources.

Climate

Rainfall. The country's rainfall pattern varies according to geographical location, as well as seasons. Since the 1950s, the total annual rainfall has increased in areas like Central Luzon, while it has declined in Northern Luzon (Figure 2.2_1). Extreme rainfall has declined in most parts of the country.

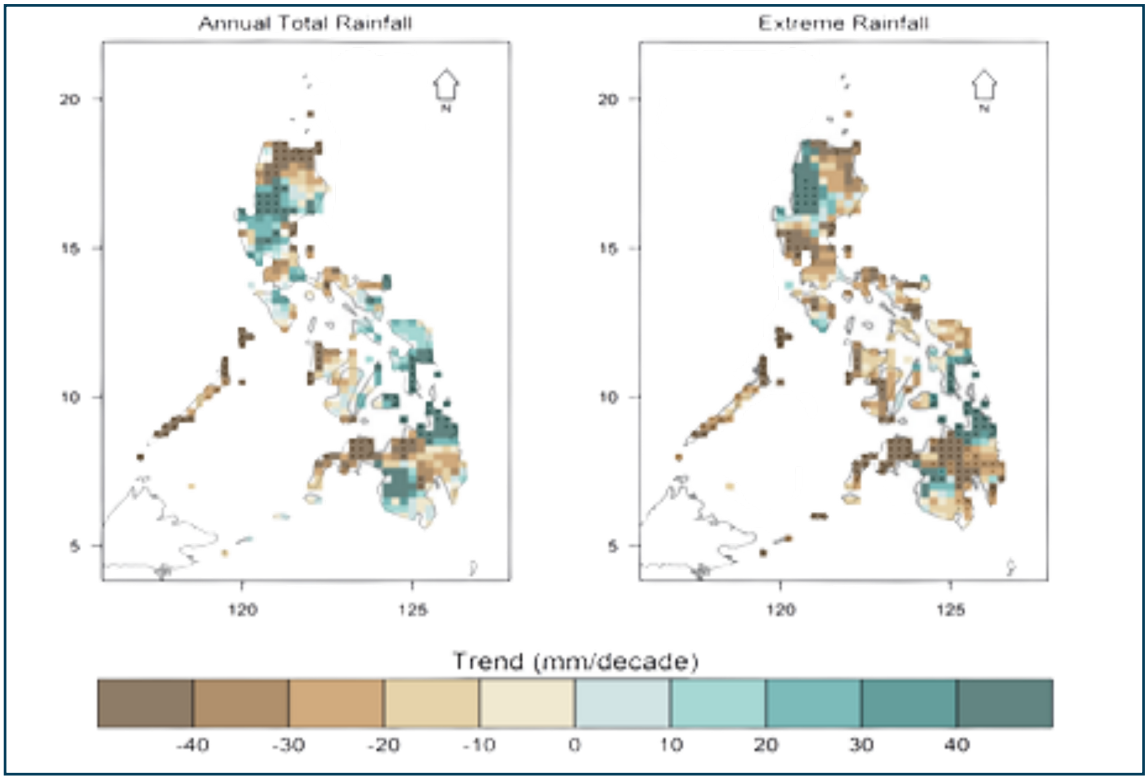

Figure 2.2_1. Observed Trends in Annual Total Rainfall and Extreme Rainfall in the Philippines during the period 1951-2010.
Source: PAGASA (2018)

Air Temperature. The country's air temperature has been steadily warming, with an average increase of 0.68°C over the past 65 years (Figure 2.2_2). This is consistent with the global warming trends, which have been attributed to the rise of greenhouse gases such as carbon dioxide, methane, and nitrous oxide. Since the start of the industrial revolution, average global temperature has risen by about 1°C (IPCC 2018).

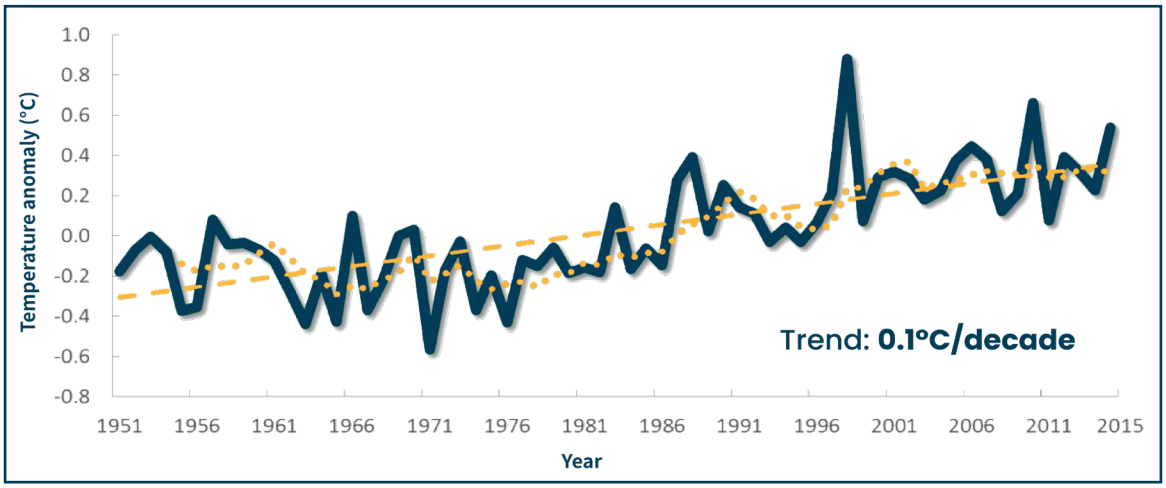

Figure 2.2_2. Air Temperature Anomaly in the Philippines from 1951 to the Present.
Source: DOST-PAGASA (2018)

Extreme Weather Events. While there are no significant differences in the number of tropical cyclones entering the Philippines and making landfall since 1951 (Figure 2.2_3), there has been a minimal increase in the number of tropical cyclones with maximum winds of more than 170 kph (DOST-PAGASA 2018).

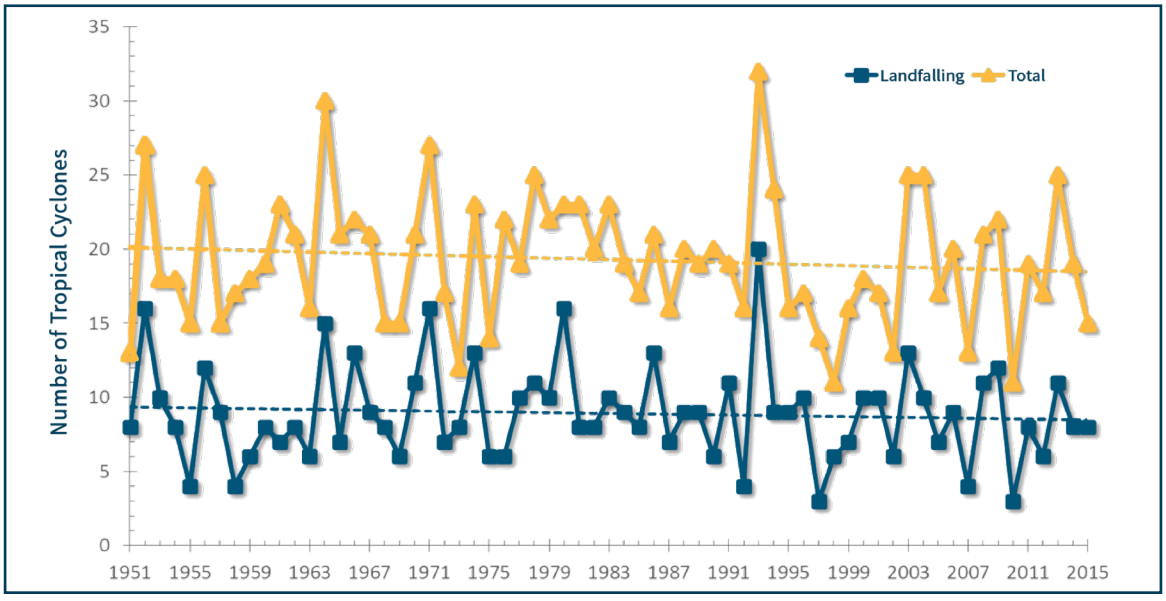

Figure 2.2_3. Annual Number of Tropical Cyclones in the Philippines from 1951 to 2015.
Source: DOST-PAGASA (2018)

Adaptation to climate hazards. The Climate Change Commission (CCC), the Department of Environment and Natural Resources (DENR), the Department of Science and Technology (DOST), and the Office of Civil Defense are the key government agencies addressing the climate hazards. Other departments are also addressing climate change impacts on their plans and programs.

There are numerous adaptation practices and technologies available for minimizing the impacts of climate hazards. For example, the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA) has steadily improved its capability to forecast tropical cyclones and heavy rains through the use of computer simulations and radar technology. The CCC has launched education campaigns to inform the public of the dangers posed by global warming.

Land State and Trends of Global and Sub Global Terrestrial Natural Resources

Land is a principal resource on which biodiversity, livelihoods, supply of food, freshwater and other ecosystem services, depend. Use of land for various activities directly affects more than 70% of the global, ice-free land surface (IPCC 2019a). Land also plays an important role in the climate system being a source and a sink of greenhouse gases (GHGs) and plays vital roles in the exchange of water, nutrients and aerosols between the land surface and the atmosphere (IPCC 2019a). Figure 2.2_4 shows how land productivity is influenced by land use change largely associated with forestry, agriculture and urban development (UNCCD 2017).

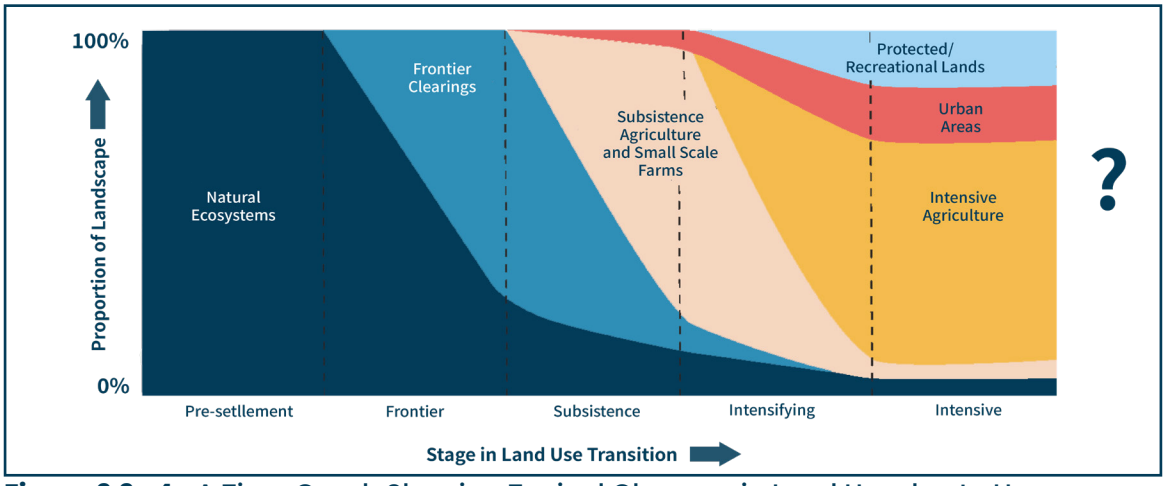

Figure 2.2_4. A Time Graph Showing Typical Changes in Land Use due to Human Settlement and Expansion.
Source: Jägermeyr et al. (2017)

Specifically, land use change is largely driven by tropical deforestation and agricultural expansion, temperate reforestation or afforestation, cropland intensification and urbanization (Song et al. 2018). Among these, agricultural expansion is the most widespread form of land-use change, with more than a third of the global land surface being used for agriculture (UNCCD 2017).

Between 25% and 33% of the land's potential net primary production is already being used for food, feed, fiber, timber, and energy. One study estimated the total annual value of the world's terrestrial ecosystem services is approximately equivalent to the annual global GDP (IPCC 2019a). Land use has also been linked to the emergence of bat-borne Nipah virus in Malaysia, cryptosporidiosis in Europe and North America, and a range of food-borne illnesses globally.

Increasing tropical deforestation, along with infrastructure and urban development, modifies natural habitats and the transmission of infectious diseases such as malaria in Africa, Asia, and Latin America. In addition, disturbance of wildlife habitats is a growing concern, since 75% of human diseases have links to wildlife or domestic animals (Foley et al. 2005).

Forests. The total forest area of the world is 4.06 billion hectares, which currently roughly translates to 0.5 ha per person. Forest area as a proportion of total land area (SDG Indicator 15.1.1) decreased from 32.5% to 30.8% between 1990 and 2020 representing a net loss of 178 million hectares of forests.

However, the average rate of net forest loss declined by roughly 40% between 1990–2000 and 2010–2020 (from 7.84 million ha per year to 4.74 million ha per year), the result of reduced forest area loss in some countries and forest gains in others (FAO 2020). Given this, the world is not on track to meet the target of the United Nations Strategic Plan for Forests (UN 2017) to increase forest area by 3% worldwide by 2030 relative to 2015 (FAO 2020). In large parts of the biodiverse tropics, 32 million hectares of primary or recovering forests were lost between 2010 and 2015 (IPBES 2019).

The extent of tropical and subtropical forests is increasing in some countries but is decreasing in others, while the global extent of temperate and boreal forests is generally increasing. The continuing decline of tropical and subtropical forests in some countries is driven by economic development, technological and demographic factors, expansion of agriculture, grazing and urban development. Among these drivers, agricultural expansion is the most influential (Annunzio et al. 2015; FAO and JRC 2012). About 70%-95% of forests loss in the tropics are due to conversion to agriculture (Holmgren 2012).

Forests play a vital role in the mitigation of climate change by sequestering carbon and storing it in biomass form. Forests absorb 2.6 billion tons of carbon dioxide each year, about one-third of the carbon dioxide released from the burning of fossil fuels (IPCC 2014).

On the other hand, deforestation is one of the major sources of GHG emissions, contributing around 20% of the total GHGs in the atmosphere. Conversely, climate change is one of the significant drivers of forest degradation and deforestation. Most of the drier regions of the world experience reduction in forest cover due to increased forest fire occurrences, outbreaks of pests and diseases triggered by excessive warming and drying. In

other regions, climate change positively contributes to enhancement of forest growth and expansion of forest cover due to increase in precipitation and carbon fertilization.

Sustainable forest management, forest landscape restoration, and forest law enforcement are proven strategies for keeping forests healthy and resilient, and to restore degraded forests and deforested areas to their multifunctional state. Healthy forests help reduce GHGs in the atmosphere through carbon sequestration while, at the same time, providing a variety of services essential to a secure, progressive, and resilient people.

Biodiversity. Biodiversity is one of the pillars of sustainable ecosystems, because of their ability to provide an array of services that are essential to a progressive and secure society. However, global biodiversity is under siege by combined pressures from land use change, climate change, pollution, and invasive alien species (IPBES 2019). Land use change is mainly driven by agricultural expansion and overexploitation, and to a lesser extent by tree plantation development, grazing, and human settlements that lead to deforestation, and forest degradation and fragmentation (Figure 2.2_4). Climate change-induced disasters and other disasters due to natural hazards also cause forest fragmentation.

Consequently, the average abundance of native species has declined by at least 20% in most major terrestrial biomes with potentially harmful impacts on ecosystems and their services rendered to people. Most of this decline began in 1900 and is likely accelerating. Native biodiversity in areas of high endemism has often been negatively affected by invasive alien species. Populations of wild vertebrate species have tended to decline over the last 50 years on land, in freshwater, and in the sea (IPBES 2019). On average, species continue to move closer to extinction. Nearly 25% of species of well-assessed taxonomic groups totaling one million species are threatened with extinction unless the drivers of biodiversity loss are significantly reduced.

Wild animal populations have shrunk by more than two-thirds since 1970, and have continued to decline since 2010. The number of extinctions of birds and mammals would likely have been at least two to four times higher if conservation actions were not taken over the past decade (UNCBD 2020). Significant progress has been achieved in improving the understanding of the biosphere since 2010 through progress in the generation, sharing, and assessment of knowledge and data on biodiversity, big-data aggregation, advances in modelling, and artificial intelligence. However, major imbalances remain in the location and taxonomic focus of studies and monitoring. Information gaps remain in the consequences of biodiversity loss for people, and the application of biodiversity knowledge in decision making is limited.

Agriculture. Most of the arable lands of the world are already in use. However, there are still sufficient land resources that can be developed and made productive with the provision of adequate resources and reversal of the neglect in agricultural research and development in recent decades (FAO 2009). The challenge is that the remaining land resources that can be developed are unevenly distributed across the world.

Agricultural crop production has increased almost threefold since 1970 and was valued at USD 2.6 trillion in 2016. Currently, productivity in 23% of the global terrestrial area has been reduced by land degradation that puts at risk between USD 235 billion and USD 577 billion in annual global crop output due to pollinator loss (IPBES 2019). Infrastructure and urban development already cover 60 million ha (UNCCD 2017) and are likely to have encroached into crop lands. Soil erosion and drought are also significant causes of agricultural land degradation, and this is exacerbated by climate woes.

Soil. The likely range of global soil erosion by water is 20 to 30 gigatons per year while tillage erosion is about five gigatons per year. Rates of wind erosion are highly uncertain with around 430 million ha of drylands being particularly susceptible. Erosion rates on hilly croplands in tropical and subtropical areas may be as high as 50 to 100 tons per ha per year, with a global average of 10-20 tons per ha annually (FAO and ITPS 2015).

Major impacts of soil erosion include loss of soil fertility, siltation of rivers, lakes, farms, coastal and marine areas, and water quality degradation. Soil loss, which is rich in soil organic carbon is also a major source of GHG emission that fuels climate change (FAO and ITPS 2015). Conversely, climate change is a major factor of soil loss by enhancing rainfall in areas with lots of rainfall, and by impinging on water supply in dry areas where rainfall is decreasing.

Timber. There is sufficient global timber supply from industrial forests of about 1.2 billion ha half of which is in high-income countries and only 8% in low-income countries (UNCCD 2017). Up until 2005, global forest plantations have been increasing, with the largest increase taking place in Asia, among the major timber producing regions in the world.

Expansion of global forest plantation from 1990 to 2005 is projected to sufficiently meet the growing global demand for timber that is expected to more than triple in 2050 compared to 1990 estimate (Ince 2010; Cuong et al. 2020). In 1990, forest plantations in Asia covered around 29 million ha which increased to approximately 45 million ha in 2005 (Ince 2010). The expansion of forest plantation in Asia is, however, uneven across sub-regions, with the largest expansion taking place in East Asia, courtesy of the aggressive plantation development program of China. In some countries of Southeast Asia like Vietnam, the increase in forest plantation has also been remarkable, and is attributable to strong national and local government support.

Most tropical forests are still not managed sustainably (UNCCD 2017). Given that the right policies and governance mechanisms are put in place, sustainably managed natural forests could provide additional sources of timber in the future.

Global Status and Trends on Coastal and Marine Resources

The oceans cover more than 70% of the earth's surface and form the largest life-support system of the planet. The ocean also provides various ecosystem services. It nurtures biodiversity; stores carbon and stabilizes the climate. It directly supports human well-being through food, minerals and other industrial materials, energy resources; and cultural and recreational services.

The contribution of ocean-based industries to economic output and employment is very significant. In 2010 this was valued very conservatively at USD 1.5 trillion, or approximately 2.5% of world gross value added. Direct full-time employment in the ocean economy amounted to around 31 million jobs in 2010. The largest employers were industrial capture fisheries, with over one-third of the total and one-quarter from maritime and coastal tourism. Growth of these industries is expected to accelerate.

The Organization for Economic Cooperation and Development estimates that, by 2030, USD 3 trillion will be generated annually from ocean sector industries. Ocean industries are anticipated to employ approximately 40 million full-time equivalent jobs. Strong growth is expected in marine aquaculture, offshore windmills, fish processing, and shipbuilding and repair (OECD 2016).

Given the rapid development, scaling-up and diversification of uses of the oceans on the one hand, and the deteriorating health of the ocean on the other, a holistic "blue economy" approach has been put forward by the international community to consider the health of the oceans and seas, and to balance the three dimensions of sustainable development: economic, social and environmental (UN 2016a). This new paradigm of ocean economy, balances the long-term capacity of the assets, goods and services of marine ecosystems, and considers social inclusiveness (World Bank and UNDESA 2017).

Key Drivers and Impacts. The expansion of economic activities in the ocean is driven by the increase in global population, economic growth, and advancements in technology. Technological advancements over the past decades have rendered even the most remote parts of the ocean accessible—including discovery of new, valuable resources in the deep seabed. The intensification of the use of the oceans will further threaten the already poor health of the oceans and, thus, the long-term sustainability of the ecosystem services from the sea.

Development in coasts and oceans are impacted by activities related to acquisition of food, materials and use of space for various activities. The coasts and nearshore waters are also very vulnerable to land-based pollution, in particular agricultural run-off, chemicals, and macro- and micro-plastic pollutants that feed into the ocean from rivers.

Climate change has encompassing impacts, given the strong interaction between oceans and atmosphere. Resulting environmental changes (increase in temperature, sea level rise, ocean acidification) will directly affect the spatio-temporal patterns of biotic (e.g., distribution and abundance of biodiversity including fishery resources) and abiotic resources (e.g., energy sources—temperature, wind) and human activities at global and regional scales.

Source of Food. With the increase in global population, food demand is also rising. Food from the sea has an important role in food security and global supply. Production from the wild fisheries and farmed species in the ocean accounts for 17% of the global production of edible animal protein (Costello et al. 2020).

However, exploitation of fishery resources has exceeded sustainable levels in many regions. The decline in the productivity of the oceans is further exacerbated by pollution and climate change (Barange et al. 2018). Likewise, the expansion of marine aquaculture (mariculture) production to supplement production for seafood is constrained by climate change and concerns on sustainability given the new or increased pressures on marine ecosystems, i.e., aside from pollution, infectious diseases and the related emergence and spread of drug-resistant pathogens (Reverter et al. 2020).

Source of Raw Materials. Apart from living resources for food, the ocean encompasses a wide range of biotic, abiotic, and intangible resources (Jouffray et al. 2020). Marine organisms are sources of raw materials for industries other than for food (e.g., seaweed derived products, ornamental trade). Moreover, with the advent of biotechnology and technologies for the exploration of the deep sea, access to marine genetic resources from areas beyond nation jurisdiction (ABNJ), which include vast areas of the deep sea—including poorly-known habitats (hydrothermal vents, sea mounts) with unique assemblages of organisms, are currently hotly contested. Recognizing the legal gap in managing resources in ABNJ, an international legally binding treaty was developed under the United Nations Convention on the Law of the Sea (UNCLOS) (Rabone et al. 2019).

Of the abiotic resources, the oil and gas sector is the largest ocean-based industry. Nearly 70% of the major discoveries of hydrocarbon deposits between 2000 and 2010 happened offshore, and as shallow-water fields become depleted, production is moving toward greater depths. Aside from exploration and exploitation of hydrocarbons, the prospects for vast quantities of natural gas hydrates as well as rich mineral resources in deep-sea mining has propelled unprecedented expansion from exploration to exploitation.

Contractors' interest in claiming large tracts of seafloor with exclusive rights for exploration increased from just eight in the first four decades (1970–2010) to 25 in the next four years (2011–2015) (Sharma 2017). The International Seabed Authority (ISA), was established in 1992 to regulate human activities on the deep-sea floor beyond the continental shelf.

To date, 27 contracts for mineral exploration have been granted, encompassing a combined area of more than 1.4 million sq km. However, many of the regions identified for future seabed mining are already recognized as vulnerable marine ecosystems (Miller et al. 2018).

Space for Various Uses. Infrastructure to support extraction of food and materials such as fishing boats, aquaculture farms, offshore platforms and deep-sea mining equipment, all require space in the ocean. However, the ocean space also provides the basis for a multitude of other activities at sea such as shipping, pipelines and cables, renewable energies, conservation, tourism and recreation, reclamation, territorial boundaries and associated military activities. Exploitation of Natural Resources and Climate Change

The phenomenal rate of change of activities for extraction of food and materials and the diversified need for space over the past 50 years, with a sharp acceleration at the onset of the 21st century, are intensifying the pressure on the ocean and leading to a range of synergistic, antagonistic, and additive interactions between these different uses (Jouffray et al. 2020).

Mitigating Measures and Opportunities. The diverse uses of coast and ocean resources, and the dynamic spatio-temporal changes affected by anthropogenic factors as well as natural factors, emphasized the need for better governance systems for human activities in the ocean space at all scales of governance from global to the local. Several of the interlinked UN SDGs are essential in relation to the ocean and seas, Goal 14— 'Life below Water' —specifically addresses marine issues (UN 2016b).

An **Integrated Ocean Management** (IOM) is the overarching framework for a holistic, ecosystem-based, and knowledge-based approach meant to ensure the sustainability and resilience of marine ecosystems and coastal communities. At the same time, this integrates and balances different ocean uses to optimize the overall ocean economy, as well as maintain and further develop the effective sector-based management of ocean industries.

Successful implementation of IOM requires a good understanding of different contexts, including local knowledge, environmental conditions, and scaling-up of local actions. In addition to local considerations, there are universal opportunities for action identified to help achieve IOM for a sustainable ocean economy as follows (Winther et al. 2020):

- harness science and knowledge
- establish partnerships between public and private sectors
- strengthen stakeholder engagement and stewardship
- improve capacity-building
- implement regulatory frameworks
- encompass climate change and other environmental changes in adaptive management system.

SECTION 2.3
NAVIGATING THE NEW GLOBALIZATION: THE PHILIPPINE PERSPECTIVE

Deep structural "mega-trends" have been sweeping across the world, notably the emergence of a new era of "digital globalization". These changes promise to re-shape international economic linkages, just like the previous waves of globalization relating to trade, finance, and people. This new globalization is linked to the 4th industrial revolution, which sees automation, artificial intelligence, the internet of things (IoT), and other technological trends not just reshaping the world economy, but also creating disruptions and spurring innovations in the social and political spheres.

However, the new globalization has been interrupted by the COVID-19 pandemic, which has affected over 200 countries and territories. It is crucial to understand whether the interruption will be a brief one or a mere blip. The uncertainty related to the pandemic and to certain political factors (e.g., return of populism in many economies) may point to a protracted adjustment period for broader globalization trends.

From a Philippine perspective, it is critical to understand the implications of these waves of change which are sweeping across the world.

Intended as an evidence-based foresight analysis, we map the main features of globalization and outline some initial policy directions, with a particular focus on science and technology. Its main recommendations include focusing on the Philippines' efforts at building back better from the pandemic in areas that would improve on inclusive recovery from the pandemic, and on more inclusive development during the post-pandemic period.

In addition to the COVID-19 pandemic, natural hazards also disrupted activities in the Philippines such as volcanic eruptions, consecutive strong typhoons, earthquakes, and other phenomena that might be related to climate change. More science-based support is recommended to pre- and post-disaster initiatives to mitigate risks, minimize losses, and strengthen the adaptive capacity of institutions in the country.

Globalization and the Fourth Industrial Revolution

Globalization has been a double-edged sword: it provided opportunities for innovation, economic development, and transformation of political communities, but also caused disruption and human suffering for some groups through diseases, conflicts, and financial crises (Sachs 2020).

The initial phases of globalization were characterized by the movements of people, goods, and finances. This is now shifting to the soaring flows of data worldwide—a phenomenon called "digital globalization" (McKinsey Global Institute 2016). After almost four decades of steady increases in global trade as a share of gross domestic product (GDP), the 2008 international financial crisis triggered a slowdown.

In 2019, global trade was at 60.4% of world's GDP, close to the 60.8% estimate before the 2008 crisis. When one examines the flows of goods, services, and finance as an aggregate (and as a share of world GDP), there has been tapering off since 2010. We expect this to remain this way or drop even more during the pandemic (Figure 2.3_1).

The Fourth Industrial Revolution (FIRe) fuses the physical, digital, and biological domains through technology, embedding it not only within societies but also in the human body (Schwab 2016). The FIRe is characterized by breakthroughs in artificial intelligence, nanotechnology, biotechnology, three dimensional (3D) printing, and the internet of things (IoT) among other spheres (Schwab 2016).

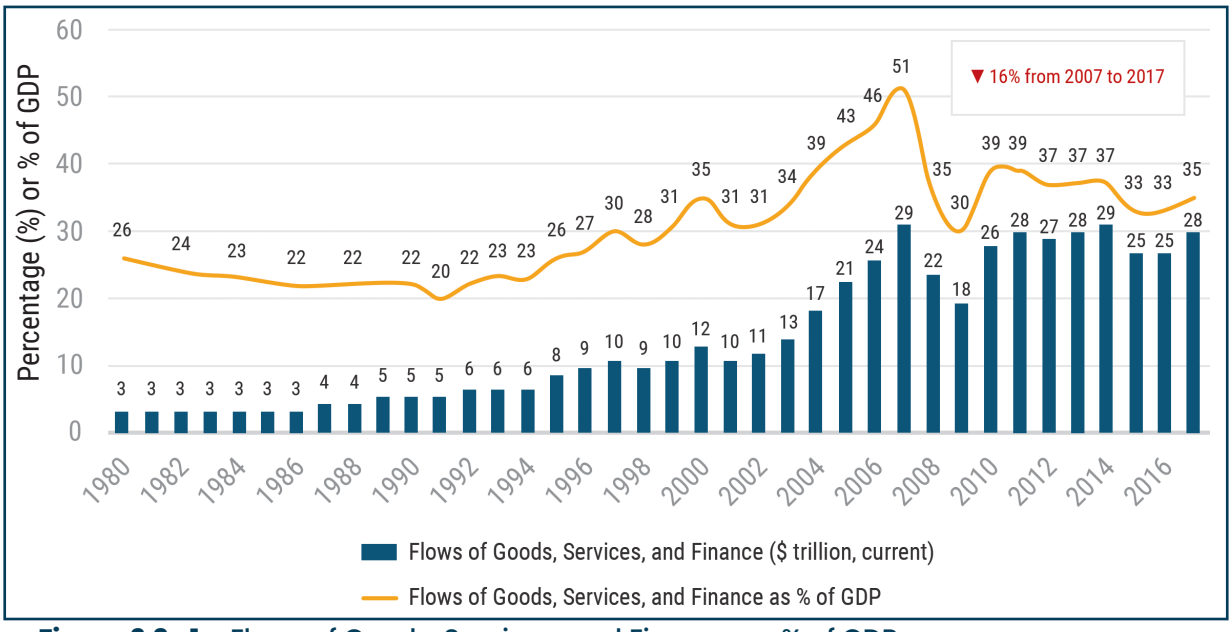

Figure 2.3_1. Flows of Goods, Services, and Finance as % of GDP.
Source: McKinsey & Company (2018)

Cross-border data flows further fuel trade and investments across countries, creating new areas for productivity enhancement and wealth creation. McKinsey Global Institute (2016) notes: "The amount of cross-border bandwidth that is used has grown 45 times larger since 2005. It is projected to increase by an additional nine times over the next five years as flows of information, internet searches, online communications, video, online transactions, and intracompany internet traffic continue to surge. In addition to transmitting valuable streams of information and ideas in their own right, data flows help to facilitate the movement of goods, services, finance, and people." (Figures 2.3_2 and 2.3_3) Virtually every type of cross-border transaction now has a "digital component". Yet these, too, raise new challenges, as the benefits of digital trade are premised on trust, which raises issues of regulation to protect privacy, consumer welfare, and secure data management (Casalini and Lopez Gonzalez 2019).

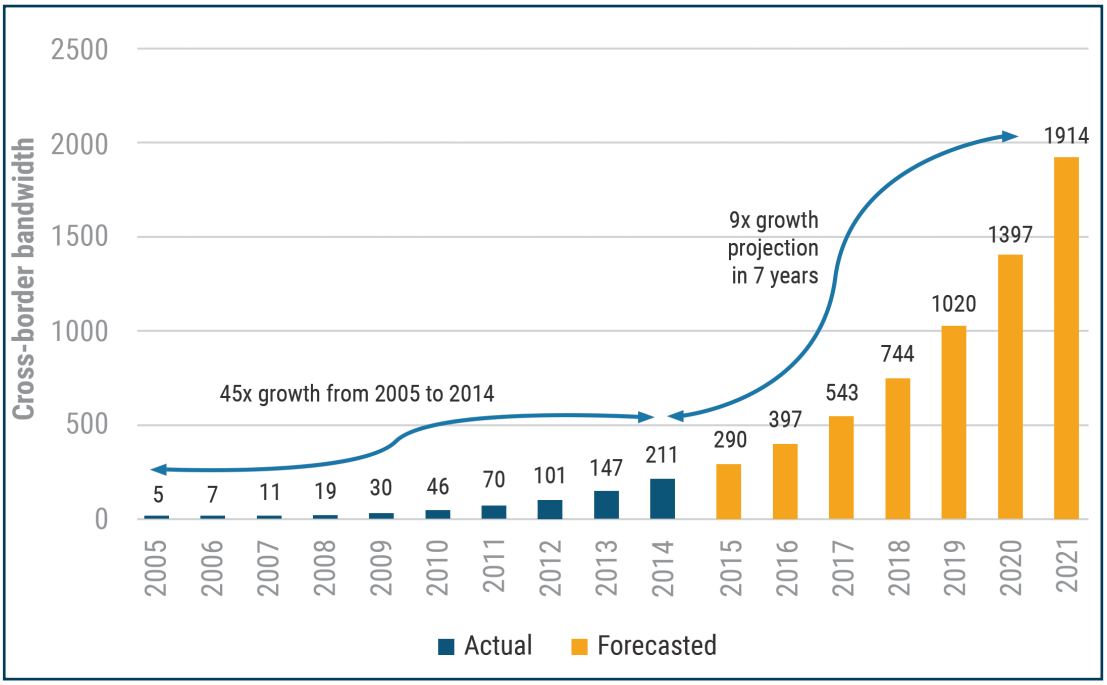

Figure 2.3_2. Cross-border Bandwidth Growth Data
Source: McKinsey Global Institute (2016)

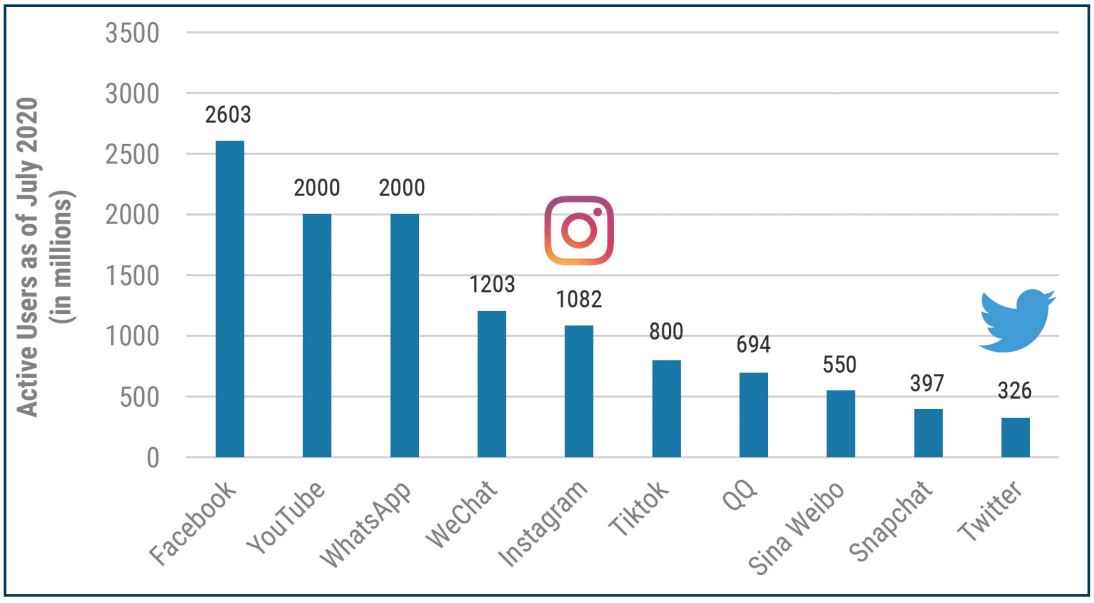

Figure 2.3_3. Digital Platforms Interconnecting People and Firms Across Borders.
Source: Statista (2020)

Across countries, there is wide variance in institutional readiness to underpin this trust. Within countries, and across firms, there is also wide variance in online access networks. In other words, the contours of this round of globalization are not as "flat" as previous eras—uneven governance and institutional quality, and disparate access to technology across and within countries augur less equal participation in this globalization round. Yet, clearly, the impact will be felt worldwide whether a country participates or not.

In the post-COVID-19 world, it is more likely that this part of international trade will increase further and faster, fueled in large measure by online connectivity that has become more important under lockdown conditions. Analysts predict that consumer behavior may have begun to permanently change under the "new normal", with e-commerce within and across borders playing a much larger economic role.

While most developed countries are already adapting to the changes brought by the FIRe, the situation will be different for developing countries like the Philippines. According to the Readiness for the Future Report of the World Economic Forum, the Philippines is classified as a "legacy country", which means a strong production capacity is present in the country (WEF 2018a). However, the Philippines is also at risk of future shocks due to its weak institutional framework, human capital, and innovation capacity.

Some aspects of the FIRe are already present in the country, with several industries and government instrumentalities adopting technologies to expedite processes and supplement capabilities. For instance, the Armed Forces of the Philippines used drones for surveillance and reconnaissance during the Marawi Siege in 2017, which helped in their operations (Franco 2017). 3D-printing is also on the rise—the first 3D-printed hotel was erected in 2015 in Angeles City, Pampanga (Tablang 2015). In terms of financial technology, platforms such as GCash have over 20 million registered users and 63,000 partner merchants nationwide, making financial transactions more efficient for Filipinos (Philippine Daily Inquirer 2019).

Unequalizing Trends: From 'Flat World' to 'Regional Trade, Tourism, and Investment Bubbles'

The COVID-19 pandemic has interrupted globalization, and it may have erected additional economic, political, and health challenges for many countries, increasing the possibility that there will be varied progress in establishing the conducive institutional frameworks for fully engaging in the FIRe.

Rather than multilateralism, increased regionalism may become even stronger in the post-COVID-19 world, akin to the tourism and trade bubbles now being promoted as part of coping strategies for countries that band

together in terms of their relative success in dealing with the pandemic (Locker 2020). Such trends may exacerbate inequality in several ways, particularly in the Philippine context.

Poverty and Hunger During the 'Great Lockdown Recession'

The social inequality among Filipinos became more pronounced as the coronavirus pandemic in the Philippines quickly shifted from a health crisis to an economic recession.

As the country was put into lockdown, thousands of businesses were forced to temporarily stop operations and, consequently, lay off millions of workers who had to rely on the government's meager financial support for their survival.

In July 2020, adult unemployment in the Philippines rose to 45.5% from 17.1% in December 2019—equivalent to 27.3 million unemployed Filipinos (SWS 2020b). While skilled workers were able to continue their employment through a work-from-home setup, less-skilled workers, especially those that perform manual labor, are the most exposed to the infection risk.

Clearly, there is an emerging divide between highly adaptive and skilled workers who can work more safely from home and maintain their productivity and jobs, and the mass number of less-skilled workers who suffer more shocks from the pandemic, and continue to face relatively higher risks under the "new normal".

The 'Matthew Effect' in Education

As part of the measures set in place by governments to contain the virus, face-to-face interactions were prohibited, which prompted schools to move their classes online. Yet, according to the National Information and Communications Technology Household Survey 2019, only 17.7% of households nationwide have their own internet access at home, and 24% have communal cellphones but only two out of 10 have communal computers (DICT 2020). The necessity to push online learning is likely to spur innovations in online education which may introduce cost-effective models that could last beyond the COVID-19 crisis. However, experts fear that the crisis is likely to exacerbate the "Matthew effect": a deepening inequality in access to education and quality of learning across the digital divide (Burgess and Sievertsen 2020; UNESCO 2020).

In addition, there is growing recognition of the necessary retooling of the education system so that countries go well beyond mere "emergency remote teaching", with key investments in both hardware (classroom connectivity) and software (notably proper teaching skills build-up). Such an education system can also be better prepared for any future pandemic, providing more options in education, with potentially fewer disruptions in learning and education outcomes.

Even without considering the digital divide, there is already an existing inequality in access to education in the country and this is evident in assessment results. In the 2018 Programme for International Student Assessment results, the Philippines scored below the average in reading, mathematics, and science among 79 participating countries from the Organisation for Economic Co-operation and Development countries (OECD 2019a). The result also noted that "socio-economically advantaged students outperformed disadvantaged students in reading by 88 score points" (OECD 2019a).

Automation and Jobs

A disease outbreak may end up accelerating many aspects of FIRe through several channels.

First, robots do not catch a colds and, in an era of global pandemics, there is a distinct advantage behind manufacturing, transport, and other systems that are less impacted by disease outbreaks and the means through which these are contained. Some analysts argue that automation is likely to have received a dramatic boost from COVID-19 (Morgan 2020). Social distancing, quarantines, travel restrictions, and lockdowns will create massive inefficiencies in the economy (e.g., a sub-optimal number of passengers in airlines, shoppers in malls, riders of mass transport, and even fewer workers in manufacturing). All of this will likely intensify the need to invest in increased efficiency-enhancing tools and technologies, possibly through big data and the IoT.

Furthermore, some of the responses for fighting COVID-19 are also drawn from the FIRe, offering a demonstration effect on how useful these new technologies are: tele-medicine, contact tracing applications, AI-powered and big-data enabled epidemiological simulations, and automation in retail, hospitals, and various other sectors (Khagram 2020).

Meanwhile, in the Philippines, even before the pandemic, analysts were already predicting that over 18 million jobs could be automated, raising the challenges of strengthening education, re-skilling for better job-matching, boosting innovation, and ample social protection and training mechanisms during the adjustment period (see among others, Albert et al. 2017; Dadios et al. 2018; and Moraje 2017).

According to the results of a survey conducted by an American consulting firm in June 2020, 80% of firms in the Philippines had ongoing digital transformation programs while 20% have not started or did not have any plans for digital transformation (Grant Thorton 2020). Among the top five industry respondents, business process outsourcing (BPOs) had the highest number of completed projects while manufacturing was one of the industries without plans for digital transformation projects. The ongoing or completed projects for BPOs were process automation (83%), data analytics (63%), and enterprise software implementation (63%), while cloud services or infrastructure migration (50%) are the projects they want to prioritize next (Grant Thorton 2020).

Analysts forecast millions of new high-quality jobs created as part of the FIRe, and the Philippines is well placed if it has an effective game-plan to compete.

The Debt Burden

As the COVID-19 pandemic dramatically impacts the Philippine economy, and given the increased reliance on debt-financed public sector responses, Filipinos will have to bear the burden of the increasing debt for the government's COVID-19 response.

According to the Finance Department, gross borrowings will reach over PhP 3 trillion in 2020, PhP 3.03 trillion in 2021, and PhP 2.32 trillion in 2022, and these borrowings will increase the country's outstanding debt to PhP 11.98 trillion in 2021 (De Vera 2020).

Although the loans can help fund the government's efforts to respond effectively to COVID-19, future generations will have to shoulder this liability. Economic growth must continue to outpace debt growth in order for the latter to be sustainable. Moreover, governance will be key so that the investments and spending do not suffer from considerable leakages.

Poor Governance and Weak Institutions

The global pandemic has disrupted many economies, yet emerging evidence suggests that the severity of its impact can be mitigated by the relative quality of the governance environment.

A novel study by Chien and Lin (2020) empirically examines the links across governance (proxied by the World Bank's Governance Indicators) and relative effectiveness in containing COVID-19 spread (proxied by daily cumulative confirmed cases) and they found evidence that: "countries with better governance had a more rapid increase but a shorter outbreak period than countries with fair or worse governance by 19.6 to 22.3 days. Most countries with better governance (84%) revealed a declining trend in COVID-19 incidence, while such a trend was less than half of fair and worse governance countries (38.5%–41.7%)" (Chien and Lin 2020). Countries like New Zealand, South Korea, Taiwan, and Vietnam are now seen to have implemented relatively effective responses to the pandemic, underpinned by strong systems and institutions, and effective leadership (Dayrit and Mendoza 2020).

While we only have prima facie evidence at this early stage, we hypothesize here that economic actors may start differentiating across governance and institutional environments, producing "bubbles" of trade, investment and tourism ties among countries (and within their jurisdictions) with similarly strong systems, excluding those without.

In terms of the quality of e-governance systems, the performance of the Philippines improved significantly from 2014 to 2016, but slightly deteriorated between 2018 and 2020. According to the United Nations (UN) E-government Development Index (EGDI), the Philippines ranked 77 out of 193 countries

worldwide in 2020 (UN DESA 2020). The EGDI measures the capability of governments to maximize technology in the delivery of public services. In terms of the level of engagement of the government with citizens measured by the e-participation index, the Philippines is at the 19th rank in 2018, 48 notches higher than its 67th rank in 2016 (UN DESA 2018).

Some 93% of national government agencies in the Philippines have web presence in 2017 (DICT 2019). Websites serve as the primary e-government channel for information; automating government processes can enhance the quality of service delivery to citizens and businesses.

One modernization initiative that may produce considerable benefits is the automation of the transactions of the Bureau of Customs (BoC), which is among the most corrupt government agencies (Presidential Anti-Corruption Commission 2018). BoC received a PhP 4 billion loan from the World Bank in October 2020 for the automation of processes, which will help strengthen efficiency and improve the business environment by reducing face-to-face interactions and delays and increase accountability (Lopez 2020).

Disasters, Climate Change, and Food Security

Between 1990 and 2018, the Philippines has been affected by 565 disaster incidents, which have caused an estimated USD 23 billion in damages (Jha et al. 2018). The continual and increasing devastation brought by strong typhoons, volcanic eruptions, and earthquakes not only constitutes significant socio-economic losses but also threatens national security.

The projected climate change impacts on agricultural production in the country is alarming. Rosegrant et al. (2015) estimated that the number of people at risk of hunger will increase by 17% by 2050, per capita GDP will experience losses of 10% annually, and that the total annual cost to the country's economy could reach over USD 3.5 billion. Furthermore, reduction in fish catch due to environmental conditions, agricultural pests, disease of crops and livestock remain issues in the sector.

Science and Technology for Inclusion: The Main Ingredients for Policy Foresight

From a mapping of the policy context, there are additional factors to consider in crafting a foresight strategy on technology and development.

First, globalization has been interrupted, and it is critical to understand whether this will be a brief interruption or a mere blip. Due to the factors related to COVID-19 and, perhaps, also the political environment (e.g., populism), this may be a more protracted adjustment period for broader globalization trends (Neuman 2020).

Second, in the immediate future, Asia and key large countries like China, India, and Indonesia will be important, not just because of their economic and population sizes (and their large emerging middle classes), but because of the

important role they play in the global economy (ADB 2020a). Nevertheless, geo-political risks also suggest that there could be some challenges ahead for the region (McKinsey Global Institute 2016; Bisley 2020; Goto 2020; Oxford Economics 2020).

While there was still uncertainty due to COVID-19 at the time this was written, reformists should not be deterred from exercising bold foresight in building the necessary elements for successful recovery from COVID-19 and the lockdown recession, while also thriving under the mega-trends characterizing the FIRe.

The FIRe is fast progressing in the physical, digital, and biological domains and challenging the ability of nations and societies in managing the emerging technologies. The scale and scope of the transformation is just starting to be understood especially on how they will impact on systems of production, management, and governance (Schwab 2016).

The disruptive technologies that have been identified by the US Council on Competitiveness (2018) -

- biotechnology
- sensorization and internet of things
- big data
- artificial intellegence
- autonomous systems
- nanotechnology and new materials

will certainly have an impact on expectations of customers, on new and improved products, on collaborative innovation and on organizational systems (Schwab 2018). Also, there is an increasing investment in Space Science and Technology coming both the public and private sectors in several countries. These are all discussed in more detail in the section on operational areas of this Foresight report.

The FIRe offers new opportunities to create new wealth. It is therefore imperative that policies be instituted so that the manner of governance will fit the modes of creating new wealth. Policies must promote sustainable development, resilience, and competitiveness. Furthermore, a more open economic environment will be crucial to helping facilitate investments into the Philippines that carry with them the potential for new technology, hence increased productivity and employment opportunities.

In view of these rapid and disruptive developments in science, technology, and innovation, we need to have the numbers and quality of human capital in STEM (Santiago et al. 2008), access to universal healthcare, capacity for resilience during disasters, access to internet as a public good, and institutions to facilitate technology transfer.

We need to institute policies that will maintain the knowledge infrastructure that facilitates the seamless flow of information in the National Innovation

System including market opportunities for Philippine products. In this regard, the active participation of the micro, small, and medium enterprises must be assured. An assistance system must be set up to guide the sectors of the economy as they adopt new production technologies, produce new products that can compete in the global market. The technological choices that will be made by the Philippine government and private companies must be consistent with our participation in the global effort to mitigate climate change and our commitments to the UN Sustainable Development Goals.

Lastly, the greatest societal concern would be the growing inequality that may result from the Fourth Industrial Revolution especially those who may not have access to physical and intellectual capital (Schwab 2016).

Conclusion

To ensure that the Philippines can reap the benefits of the FIRe, the government needs to increase and protect investments in human capital by building a more crisis-resilient and inclusive healthcare system, and equipping the vulnerable population with STEM education, as well as specialized education to combat disinformation.

Government needs to be agile and innovative in creating new livelihood opportunities as the disruptive forces in the economy start to operate. Leveling the playing field should be accompanied by opportunities to earn a decent living.

Lastly, barriers in technology adoption among businesses and populations need to be addressed through flexible and adaptable government policies. Promoting strong competition across sectors will be crucial in facilitating an environment conducive to strong innovation and technology flows.

Taken together, all these investments emphasize how science and technology can be a force for inclusion, and for lowering inequality. This policy orientation will be critically important in the decades to come, particularly as many mega-trends reshape economies and societies, on top of the adjustments that COVID-19 already demands.

Underpinning all these technology strategies should be strong institutions and good governance, given the double-edged nature of technology, and the need to manage the inevitable disruptions triggered by this coming globalization wave.

SECTION 2.4
SPACE EXPLORATION

The unique view from space has driven great advances in knowledge that spurred innovation and discoveries that have greatly benefited mankind. Space has enabled a global perspective that has been used to address many of the critical issues that are confronting humanity especially anthropogenic environmental and climate change. These issues have been exacerbated by the exponential increase in population that has caused severe stress on our natural resources and the environment. The desire to respond to the needs of a growing population has also led to the use of energy sources and transportation systems that have caused serious pollution of the environment and increases in greenhouse gases that are expected to alter the climate.

To meet these challenges, many countries have launched satellite Earth Observing Systems (EOS) in order to collect much-needed global data that can be used in the study of Earth's climate and environmental system through phenomenological and modeling studies. Satellites have also revolutionized worldwide navigation and telecommunications systems and have greatly improved our mobility and the ability to communicate with each other globally.

Benefits of Space Technology and Exploration

Satellite EOS were launched in recent decades to help address pollution and deforestation.

Among the specific challenges that need to be addressed are the constant basic need for freshwater and food, and the anticipation of and response to natural disasters. Through space technology, it is possible to detect sources of pollution that affect the quality and availability of freshwater for domestic use; we need such information to effectively manage water supply. Satellite data can also be used to monitor extent and yield of agricultural crops. The ability to detect and quantify precipitation and soil moisture has also provided guidance on how to optimize agricultural productivity. Satellite data have also led to accurate forecasts of extreme events that have significantly improved risk management, leading to considerable decline in deaths and

property loss. The data have also been useful in the management of flooding, landslides, soil erosion, coral bleaching and harmful algal blooms.

The military applications of satellite data are likewise legion but are usually classified. We can mention here only the publicly-known uses for military strategies, such as the ability to detect ships, aircraft, submarines and possible intrusions into our territorial waters. The use of high-resolution data (<3 meters) also allows for the characterization of enemy troop movements that enables the military to be prepared for impending attacks.

The enormous applications of space technology to the needs of the civilian population cannot be ignored. In industry, technology transfer led to the availability of precision global positioning satellite systems that drastically improved navigation, crystal silicon solar power cells that provide clean energy, long-lasting tires for vehicles, small cameras that are now incorporated in smartphones, ski boots, laptops, computer mouse, wireless headphones, home insulation, thermoelectric de-icing system for aircraft and electrolytic water purification system for swimming pools and domestic needs. In medicine, space technology has led to the development of ultraviolet-blocking sunglasses, computerized axial tomography scans, cochlear implants for hearing aid, ear thermometer and foil blankets. The development of safe pre-packaged foods and freeze-dried technology initially intended for astronauts have also led to the commercialization of these products for general public use. A quantitative summary of the extent to which different sectors of society benefit from space technology is depicted in Figure 2.4_1. It is apparent that among the most frequently cited are overall economy, environmental management, transport and urban planning, research and development, and science and climate monitoring and meteorology (OECD 2019b).

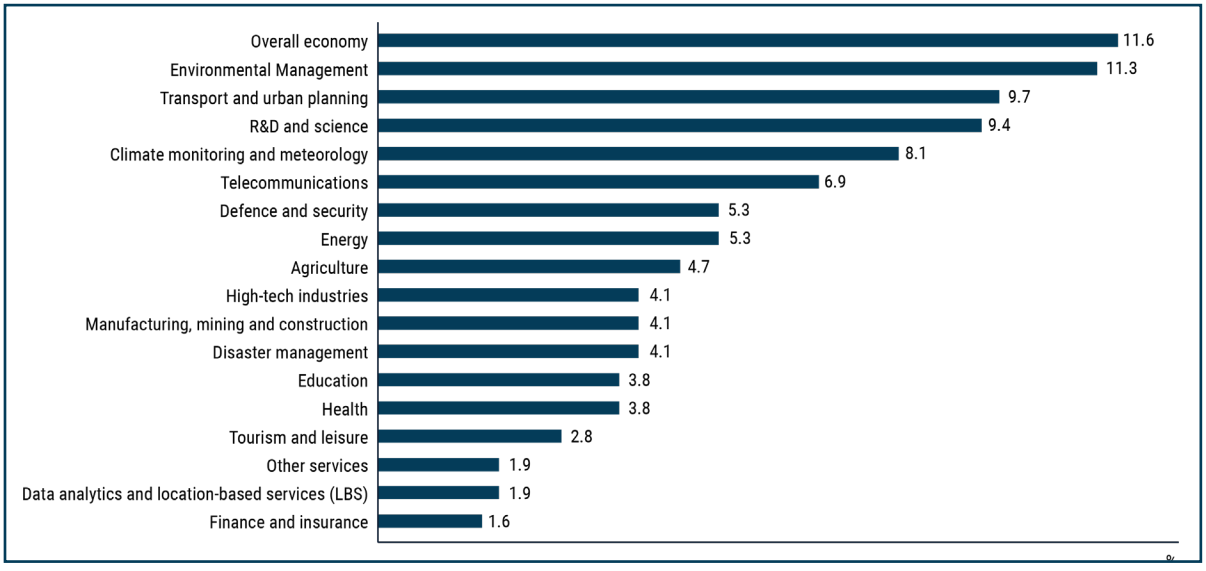

Figure 2.4_1. Selected Sectors that Benefit from Socio-economic Effects Derived from Space Investments.

Source: OECD (2019b)

Notes: The literature covers 77 impact assessments and programme evaluations published between 1972 and 2018.