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REGIONAL ASSESSMENT REPORT EXAMINING THE INTERLINKAGE BETWEEN SCP AND REGIONAL ISSUES IN ASIA

Potentials and opportunities for improvement by countries and businesses

UNITED NATIONS ENVIRONMENT PROGRAMME

Regional assessment report examining the interlinkage between SCP and regional issues in Asia

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Suggested citation

SWITCH-Asia RPAC -TERI (SWITCH-Asia Regional Policy Advocacy Component and The Energy and Resources Institute) (2022), Regional assessment report examining the interlinkage between SCP and regional issues in Asia, Authors: S. H. Gheewala, H. U. Ghani, P. Nilsalab, P. Pongpat, A. Farooq, A. Mahmood, G. A. Adeniyi, H. Akbar, and K. Fangmongkol, Output under SWITCH-Asia Regional Policy Advocacy Component Supported by European Union.

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Contents

List of figures

List of tables

Abstract

The changing consumption and production patterns have emerged as a critical challenge for the member states of Asia. The region is facing several issues due to the intensive use of resources and excessive pollutant emissions. In this study, a regional assessment is carried out providing a comprehensive analysis of the interlinkages between sustainable consumption and production indicators and regional issues in the Asian region throughout the DPSIR framework, i.e., drivers, pressures, state, impacts, and responses. Overall, the increase in population, urbanization, industrial expansion, and economic growth has led to an increase in renewable energy, material use, and GHG emissions. In recent decades, consumption and production patterns have shifted dramatically, resulting in resource depletion and pollution far beyond the ecosystem's regenerative and assimilative capacity. Resource depletion and pollution are posing substantial risks to the key sectors, particularly the industrial and agricultural sectors, which are the largest contributor to the economy. This effort is expected to contribute towards the improvement of SCP performance in the region and solve the regional issues through capacity building, situation awareness, and following the best practices

Acknowledgements

This report is produced as part of the project "strengthening resource efficiency and sustainable consumption and production" by the European Union SWITCH-Asia Regional Policy Advocacy Component, implemented by the United Nations Environment Programme (UNEP) in collaboration with The Joint Graduate School of Energy and Environment, King Mongkut's University of Technology Thonburi, Thailand. This report aims to investigate the relationship between SCP and regional issues or country problems by analyzing the current situation and impacts of consumption and production patterns in key sectors. The profiles of the six Asian economies (i.e. China, India, Indonesia, Pakistan, Thailand, and Vietnam) are examined in detail in terms of natural resource consumption. Country studies on SCP implementation are looked at as a model for solving issues or country problems in selected significant sectors. Overall, this will aid in the implementation of SCP actions to solve the regional difficulties and/or countries' problems.

The authors would like to thank the assistance and support of the SWITCH-Asia Regional Policy Advocacy Component, implemented by the United Nations Environment Programme. The authors also acknowledge the financial support provided by the European Union through the SWITCH-Asia Project.

Abbreviations

23/NQ/TW	Vietnam's new industrial policy
4IR	Fourth Industrial Revolution
AEDP	Alternative Energy Development Plan
ArcGIS	Aeronautical Reconnaissance Coverage Geographic Information System
ASEAN	Association of Southeast Asian Nations
ATI	Al-Rahim Textile Industries
BAU	Business as Usual
BTU	British Thermal Unit
CIP	Competitive Industrial Performance
COP	Conference of The Parties
CSIRO	Commonwealth Scientific and Industrial Research Organization
DMC	Domestic Material Consumption
DPSIR	Driver-Pressure-State-Impact-Response
EEDP	Energy Efficiency Development Plan
EEP	Energy Efficiency Plan
FAOSTAT	Food and Agriculture Organization Corporate Statistical Database
FYP	Five-Year Plan
GAP	Good Agricultural Practice
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GNI	Gross National Income
GW	Gigawatt
HDI	Human Development Index
IEA	International Energy Agency
INDC	Intended Nationally Determined Contribution
INDC	Intended Nationally Determined Contributions

INR	Indian Rupees
IPCC	Intergovernmental Panel on Climate Change
IREDA	Indian Renewable Energy Development Agency
IRENA	International Renewable Energy Agency
LED	Light-Emitting Diode
LTS-LCCR	Long-Term Strategy for Low Carbon and Climate Resilience
MF	Material Footprint
MOE	Ministry of Energy
MRF	Materials Recovery Facility
MW	Megawatt
MWh	Megawatt-hour
NAMA	Nationally Appropriate Mitigation Action
NAP	National Action Plan
NAPCC	National Action Plan for Climate Change
NDC	Nationally Determined Contribution
NEEC	National Energy Efficiency and Conservation
PDPD7	National Power Development Plan 7
PEP	Power Development Plan
PPP	Purchasing Power Parity
PTB	Physical Trade Balance
PV	Photovoltaic
REC	Renewable Energy Certificates
REDS	Renewable Energy Development Strategy
RPJMN	Rencana Pembangunan Jangka Menengah Nasional
RUEN	National Energy Master Plan
SBY	Susilo Bambang Yudhoyono

SCG	Siam Cement Group
SCP	Sustainable Consumption and Production
SCP-HAT	Sustainable Consumption and Production Hotspots Analysis Tool
SDG	Sustainable Development Goals
SECI	Solar Energy Corporation of India
SEDP	Socio-Economic Development Plan
SMEs	Small and Mid-Size Enterprises
SZW	Saahas Zero Waste
TFEC	Total Final Energy Consumption
TJ	Terajoule
UK	United Kingdom
UN	United Nations
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNIDO	United Nations Industrial Development Organization
US / USD	United State Dollar
USA	United States of America
VSPP	Very Small Power Producers
WTO	World Trade Organization

Chapter 1 Introduction

1.1 Background

The 21st century is believed to be the Asian century as Asia is evolving as the major hub of production and consumption in the world[1]. The consumption patterns in Asia are swiftly changing towards a material affluent society under the influence of increasing urbanization coupled with a fast transition from low to middle income population[2,3]. Traditionally, the people of the region have been savers instead of spenders; however, if the growing population of the region followed the same consumption patterns as the average American or European, the available resources on the planet earth will not be able to satisfy their needs and it will cause irreversible damage[1]. The economic growth in the region is also expected to continue a positive trend[4] and GDP increase has reached to around 5.8% in the year 2021[5]. Thus, it is crucial for the member states of Asia, especially the developing nations, to adopt sustainable consumption and production patterns.

In Asia, there is a huge variation in performance with regards to different sustainable development goals (SDGs) and different sub-regions. Overall, the region is off-track in achieving the targets for most of the sustainable development goals. Only for some of the goals, such as no poverty (Goal 1), zero hunger (Goal 2), quality education (Goal 4), reduced inequalities (Goal 10), and partnership for the goals (Goal 17), has there been a promising development but still it is too slow to achieve the desired targets[6]. This variable performance is mostly due to the obstacles and barriers that the region's member states face. One of the primary issues is the lack of coherence and effectiveness in policies with measured effects to establish an enabling environment with legal and economic incentives. Businesses are

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[1] Institute for Global Environmental Strategies (IGES), "Sustainable Consumption and Production in the Asia-Pacific Region Sustainable Consumption and Production in the Asia-Pacific Region," Kanagawa, Japan, 2010.
[2] https://www.statista.com/statistics/255591/forecast-on-the-worldwide-middle-class-population-by-region/.
[3] https://blog.aci.aero/rapid-urbanization-air-transport-demand-and-land-scarcity-where-will-the-industry-build-new-airports/.
[4] https://www.adb.org/sites/default/files/publication/715491/ado-supplement-july-2021.pdf.
[5] https://www.apec.org/publications/2022/02/apec-regional-trends-analysis-february-2022-update-multiple-headwinds-derail-recovery.
[6] https://www.unescap.org/sites/default/d8files/knowledge-products/ESCAP_Asia_and_the_Pacific_SDG_Progress_Report_2021.pdf.

hampered in their adoption of more efficient innovative technology due to financial constraints. Consumer awareness is a major challenge when it comes to using sustainable products. The absence of reliable information is also a significant problem that must be addressed in order to address the aforementioned difficulties[7].

Due to the strong economic growth, there has been intensive use of resources that is severely affecting the performance on responsible consumption and production (SDG12). All the subregions of Asia are struggling to reduce greenhouse gas (GHG) emissions within their targets of sustainable development goals. The sub-regions are also struggling to reduce the heavy material footprints, except South and Southwest Asia[8]. The resource efficiency performance of the region is still lagging behind the rest of the world. Here, resource efficiency means using the Earth's limited resources in a sustainable manner while minimising impacts on the environment[9]. It allows us to create more with less and to deliver greater value with less input. For instance, the consumption of national resources per unit of gross domestic product (GDP) in Asia is 60% more than the global average. Similarly, the emission of CO_2 per unit of value added is also 20% more than the global average. The region is completely off-track on consuming a global fair share of global resources[10].

Consequently, the region is facing issues such as increasing environmental problems in terms of emissions and wastes, inability to decouple the economic activities from the environmental degradation, inefficient production processes, and unsustainable use of natural resources[11,12]. Anyhow, performance is not a linear process and therefore accelerated progress towards a resource-efficient economy is a must in solving the regional issues. However, this also implies potentials and opportunities for improvement by countries and

[7] UNEP. (2021). Regional Overview — An Uptake of Sustainable Consumption and Production from the Asia Pacific Region. United Nations Environment Programme.
[8] https://www.unescap.org/sites/default/d8files/knowledge-products/ESCAP_Asia_and_the_Pacific_SDG_Progress_Report_2021.pdf.
[9] https://ec.europa.eu/environment/resource_efficiency/index_en.htm.
[10] ESCAP, Asia and the Pacific SDG progress report 2020, Bangkok, 2019.
[11] https://uneplive.unep.org/downloader#.
[12] Germanwatch, Climate Change Performance Index Results 2020. 2020.

businesses that have inadequate progress by adopting good practices such as the circular economy approach.

Currently, the effects of climate change, widening regional disparity of environmental performance, lack of consistent policies, and inefficient production processes are the main issues being faced by Asia[2]. This particular study is therefore aimed at analyzing the linkage between regional issues, mainly relevant to resource efficiency, and sustainable consumption and production (SCP). A total of 6 countries in the region including China, India, Indonesia, Pakistan, Thailand, and Vietnam are examined. The main focu is on agriculture, tourism, mobility, and manufacturing sectors. This is because preliminary investigation and expert discussions determined that these sectors were the most relevant. However, the analysis is not limited to these sectors only and some sectors have been added/removed considering their relevance for the specific indicators.

1.2 Purpose

This report is aimed at understanding the linkage between SCP and regional issues or countries' problems indicating the existing state and impacts related to the consumption and production patterns of the selected significant sectors. The critical factors affecting changes of the regional issues and/or countries' problems are identified to explore potentials and opportunities for sustainable improvement. Furthermore, country studies on SCP implementation are examined as a solution model in selected significant sectors to solve the regional issues or countries' problems. Overall, this will help in putting the SCP actions into practice in order to mitigate the regional issues and/or countries' problems as well as contribute to sustainable improvement.

Chapter 2 Methodological framework

2.1 Methodological framework

The integrated regional assessment of the interlinkages between SCP and regional issues is carried out by using the Driver-Pressure-State-Impact-Response (DPSIR) Framework policy cycle illustrated in **Figure 2-1**. The framework is developed based on the problem statement, purpose, and research questions as described in Chapter 1. The rapid increase in population, economic growth, consumerism, global affluence, increasing resource consumption, and climate change in Asia are the pressures driving the abrupt changes in SCP trends. These pressures are changing the state of both ecological and human health. The negative impacts in terms of environmental damages, human health, as well as economic and social performance are rapidly increasing. The DPSIR framework helps to understand the cause-effect relationship between economic activities and the environment. This cause-effect analysis will be followed by a detailed discussion on effective responses in terms of policy interventions (regulations, subsidies, taxes, etc.) and behavior change (awareness campaigns and education) for improving the SCP performance of the region.

This analysis evaluates the status of SCP in the region using the SCP indicators along with an in-depth discussion on the policy choices which may enable the decision makers to understand the consequences of their choices. A thorough analysis of the complex cause-effect chain helps to evaluate the effectiveness of responses[13]. A conceptual DPSIR framework for SCP assessment classifying and linking the pertaining regional issues with different regional SCP indicators is as follows.

- **Drivers/ Pressure:** driving forces are related to social, economic, and environment forces driving human activities such as population, economic growth (GDP), investment and consumption, consumerism, global affluence, enhanced use of

[13] https://www.fao.org/land-water/land/land-governance/land-resources-planning-toolbox/category/details/en/c/1026561/

resources, construction, climate change and waste and pollution, etc. These drivers increase or mitigate pressures contributing to the development of regional issues.

- **State/ Impact:** state of the interlinkage between SCP and the regional issues focusing on the 5 sectors; agriculture, tourism, mobility, and manufacturing sectors, is defined according to the condition of the country. Then, impacts are the effect of the changing state which are assessed through regional indicators including greenhouse gas emissions, waste management, trade dependency (physical trade balance and unit price of trade), material use, energy use (renewable energy), water use, land use, agricultural productivity, and inclusive green recovery (i.e., covid spending, natural capital, green spending, and green building). The state and impact will help to understand the SCP performance and regional issues caused due to the bad performance.

- **Response:** the responses by a country to the situation of SCP and the regional issues by evaluating the state and impacts. A bad performance represents the regional issues requiring the appropriate responses to solve these issues. The country responses refer to policy interventions (regulations, subsidies, taxes, etc.) and behavior change (awareness campaigns and education).

In addition to the DPSIR framework, the policy cycle[14] is adopted to analyze the role of indicators throughout the SCP cycle. Four aspects are considered in the policy cycle including problem framing (regional issues), SCP policy framing, SCP implementation, and monitoring and evaluation. This framework is developed to evaluate the role of indicators throughout the policy cycle[10]. The methodological and research frameworks to evaluate the interlinkage between SCP and regional issues are illustrated in **Figure 2-1** and **Figure 2-2**, respectively.

[14] Dovers, S. 2005, Environment and Sustainability Policy. Creation, Implementation, Evaluation, The Federation Press, Annandale.

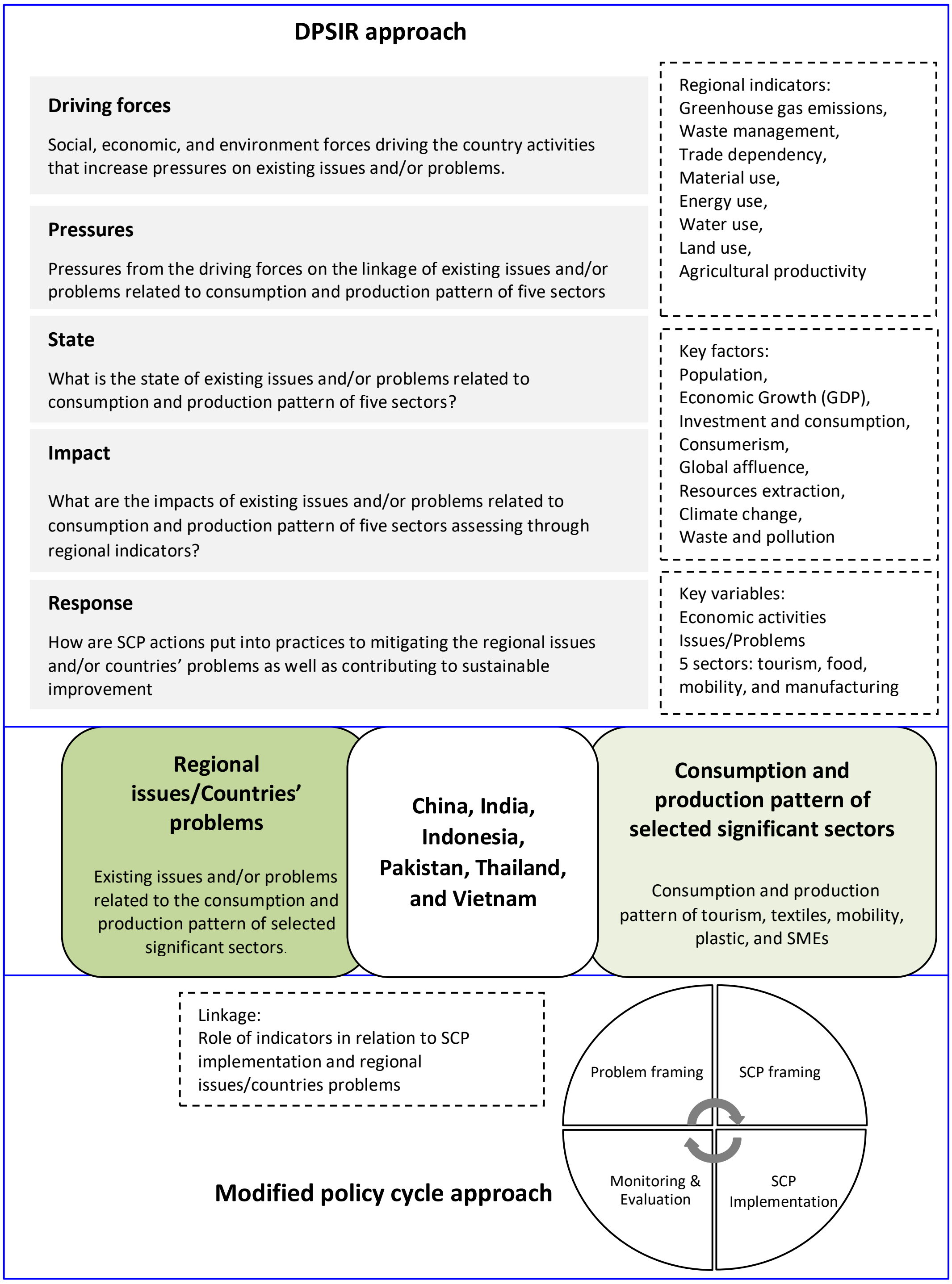

Figure 2-1 Methodological framework to evaluate the interlinkage between SCP and regional issues[15,16]

[15] https://wwz.ifremer.fr/dce/content/download/69291/913220/.../DPSIR.pdf

[16] https://www.iges.or.jp/en/publication_documents/pub/bookchapter/en/3121/SCP+Handbook+for+Policy+Makers_Asia+Ed_%281pageView%29.pdf

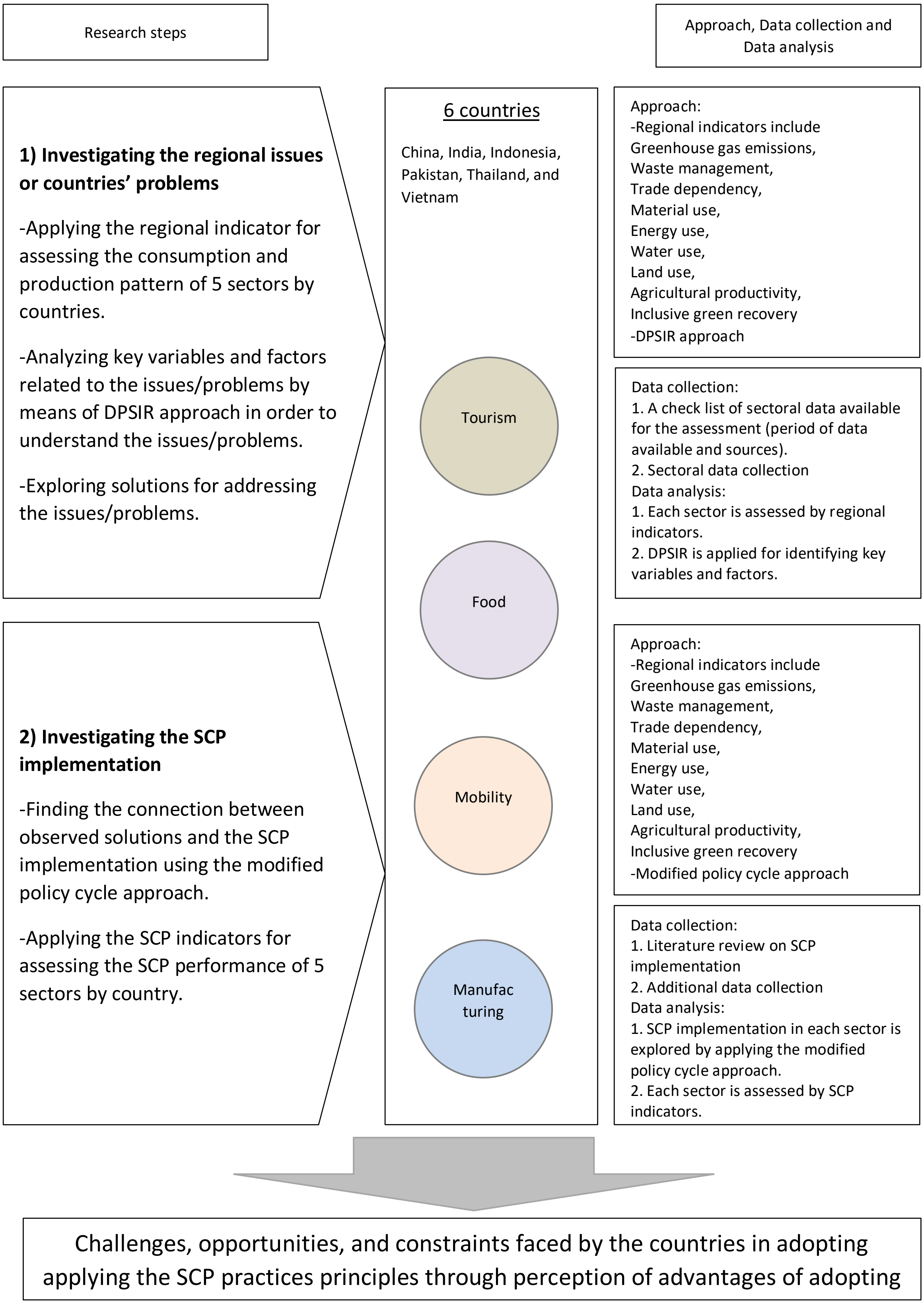

Figure 2-2 Research framework to evaluate the interlinkage between SCP and regional issues

A comprehensive analysis is made considering the selected sectors to evaluate their potential impact on the performance. The relevant SCP best practices both in policy and businesses are presented to accelerate the SCP uptake to tackle issues arising from the regional issues in Asia.

2.2 The data collection method

The data basis for the regional assessment of interlinkages between regional issues and SCP is primarily drawn from the regional indicators report[17]. Additional secondary data is also obtained through extensive literature review to acquire the most reliable data and information from recognized international, regional, sub-regional, and national sources. Quantified data with time series is preferred. However, in the absence of time series data, the quantified values for specific time have also been used. Qualitative data is used only in the case/s when quantitative data is not available. This qualitative data is acquired from the literature such as government publications, to identify patterns.

2.3 Relevance of SCP regional indicators and issues faced by Asia

The most important SCP indicators for the Asia Pacific area were selected and finalized in a recent report[17]. The indicators for the regional evaluation in this study have mostly been drawn from it. A wide and comprehensive range of regional indicators is chosen for evaluating the SCP actions of the region, factors that are influencing SCP actions, and their relevance to the regional issues. The selected indicators cover the three major pillars of sustainability (i.e., environment, economic, and social) and are used in the DPSIR framework (Driver-Pressure-State-Impact-Response). Consequently, this helps to understanding the regional issues (i.e., effect) and the drivers and pressures (i.e., cause) causing these impacts. The understanding of this cause-effect chain will help to formulate a holistic and effective response through appropriate interventions.

[17] UNEP. 2022. Regional indicators and database on resource efficiency In the Asia Pacific. Thailand.

Chapter 3 Country profiles - SCP and regional issues

Consumption and production are fundamental human activities which increasingly cause negative environmental impacts and depletion of natural resources. Out of the 17 United Nations Sustainable Development Goals (SDGs), SDG12 is dedicated to ensuring responsible and sustainable consumption and production actions which is also linked to other SDG goals. The aim of SDG 12 is to encourage sustainable consumption and production by efficient use of natural resource, sustainable management of harmful materials, promoting the efficient production practices with less pollution and waste, and encouraging the sustainable lifestyle[18]. This goal is about doing more and better with less[19]. It is also about decoupling economic growth from environmental degradation, increasing resource efficiency and promoting sustainable lifestyles. Asia has begun to accomplish the regional sustainable development goals based on sustainable consumption and production, as well as efficient management of natural resources and ecosystems. The region has become the largest user of natural resources as well as the biggest producer in the world causing to increase the regional issues such as reduced availability of resources and increased pollution and wastes [20,21]. In this part of the document, the level of adaption of SCP practices Exploring in the region by evaluating the database and analyzing the reasons of variabilities in different countries of the region. The regional issues are analyzed in relevance to the selected SCP indicators. Furthermore, relevant SCP best practices (policy + businesses) are also included from the region to trigger the response by following the best available options.

The profiles for the six national economies of Asia in terms of natural resource use (i.e., China, India, Indonesia, Pakistan, Thailand, and Viet Nam) are discussed in depth by considering the different indicators. These six countries are selected on the basis of preliminary analysis considering the intensive natural resource consumption such as material use.

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[18] https://sdg-tracker.org/sustainable-consumption-production
[19] https://www.unep.org/explore-topics/sustainable-development-goals/why-do-sustainable-development-goals-matter/goal-12
[20] https://www.iges.or.jp/en/pub/sustainable-consumption-and-production-asia/en
[21] https://www.unep.org/regions/asia-and-pacific/regional-initiatives/supporting-resource-efficiency

3.1 China

- China is the world's largest population and second-largest economy.
- Total water use in China has decreased by almost 5 percent even with the increase in economic activity.
- Domestic material consumption per capita in China is almost double as compared to Asia and the World.
- The renewable electricity-generating capacity of China has increased exponentially in the last two decades.

The People's Republic of China is the world's third-largest country, after Russia and Canada, and is located in Southeast Asia along the Pacific Ocean's coastline. Its shape on the map resembles a rooster, with a surface size of 9.6 million square kilometres and a shoreline of 18,000 kilometres. Korea, Vietnam, Laos, Burma, India, Bhutan, Nepal, Pakistan, Afghanistan, Tajikistan, Kyrgyzstan, Kazakhstan, Mongolia, and Russia are all bordering China. Marine-side neighbors include eight countries; DPR Korea, the Republic of Korea, Japan, Philippines, Brunei, Indonesia, Malaysia and Vietnam[22]. China is the world's most populous country. Its population was 1.41 billion in 2020. Furthermore, the average population growth of China was 0.31 percent in 2020. But the GDP growth rate of China was 5.9%, in 2019. In the same year, the GDP of China was 14.28 trillion USD, the second highest after the United States of America (USA)[23]. According to World Bank data, as compared to 1990, the population of China has increased by 266 million in 2020. The total population of China is shown in **Figure 3-1**.

[22] https://www.travelchinaguide.com/intro/china.html
[23] https://databank.worldbank.org/source/world-development-indicators

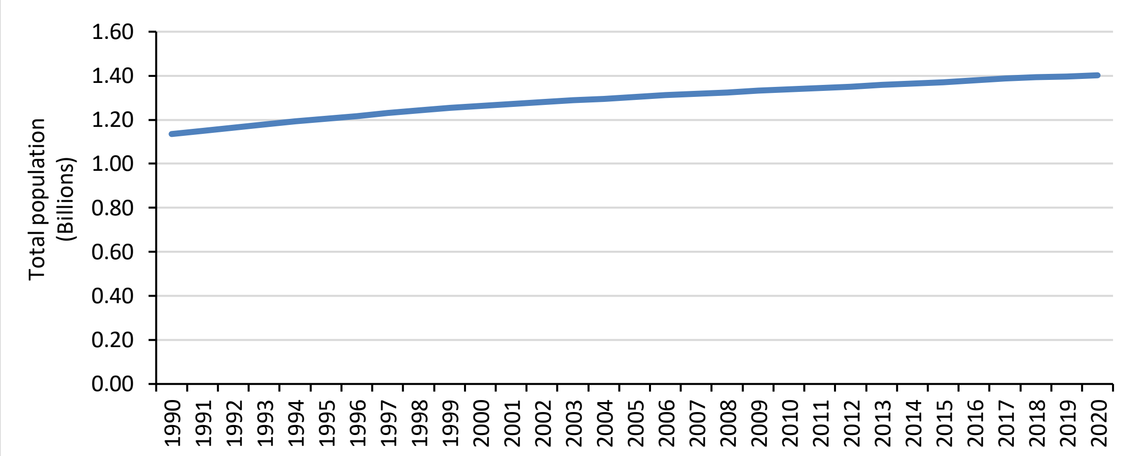

Figure 3-1 Total Population of China

Moreover, the GDP per capita of the Chinese has increased drastically from 388 to 10500 US dollars from 1990 to 2020. Similarly, the total GDP of China increased from 1.12 to 14.63 trillion US dollars from 1990 to 2020. The GDP per capita and total GDP of China are shown in **Figure 3-2**. The difference in population and GDP growth rate clearly illustrate that the Chinese economy is prospering at a decent rate.

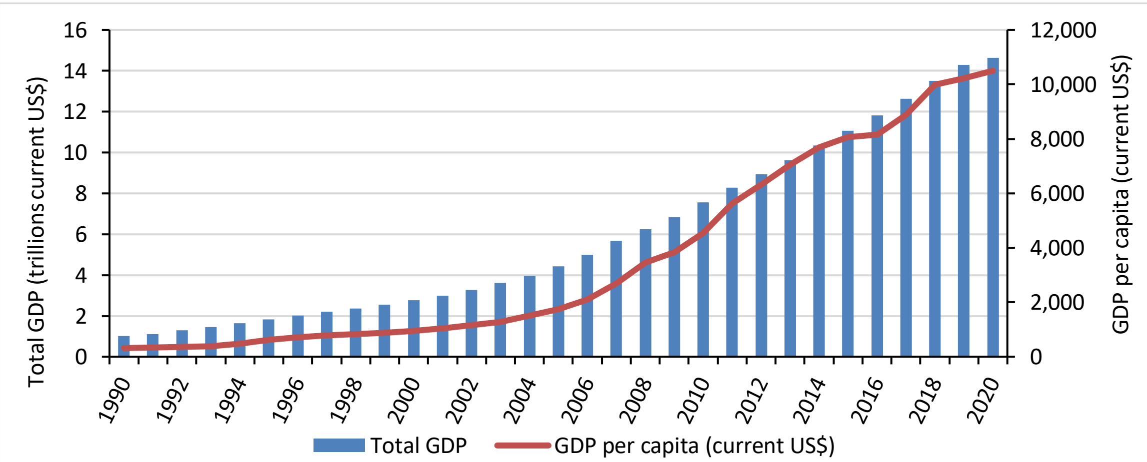

Figure 3-2 Gross domestic product per capita of China

However, the year 2020 was exceptional due to the COVID-19 pandemic, and restrictions all around which caused the decline in almost all the GDPs around the world including the USA, United Kingdom (UK). But still, the GDP of China managed to achieve a growth rate of 2.3% in 2020, which shows its economic robustness. The highest population and second highest GDP in the world make China exceptional, which causes the use of numerous natural resources, and abundant production. On a massive scale, natural resource consumption and production may put pressure on natural resources, which can have social, economic and environmental impacts on society. China is an industrialized economy. However, the agriculture sector is also playing a crucial role in the supply chain and food security of the nation. Due to the rapid expansion in urbanization, industrialization, population, and agrarian activities the increase in material use, energy use and GHG emissions are triggered by the increase in population and economic growth. However, the in-depth analysis of the China profile is presented through the DPSIR framework as shown in **Figure 3-3**. To avoid the negative impacts due to the main drivers (population, economy), the Chinese Government is trying to shift its development from conventional to green development.[24]

[24] https://sustainabledevelopment.un.org/memberstates/china

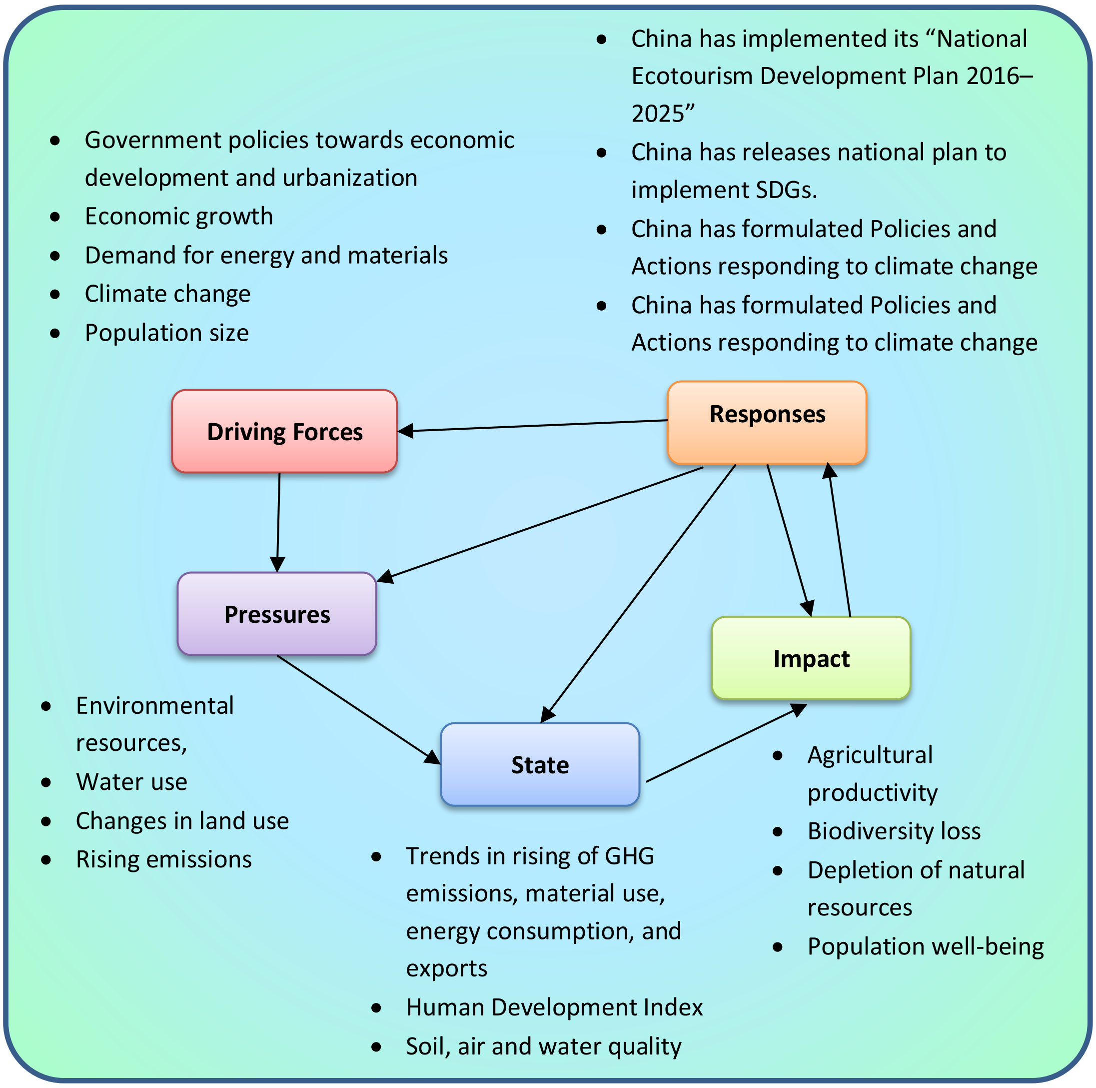

Figure 3-3 DPSIR framework of China

3.1.1 Indicators

3.1.1.1 Water use

Total freshwater use in agricultural, industry, residential, and environmental sectors (i.e., water used by environment), from all surface and subsurface sources, is reported under this indicator. Direct rainfall on crops is not taken into account[25]. The data was obtained from China Water Resources Bulletin (2011-2020)[26] for annual total water use. These indicators

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[25] UNEP (2015), Indicators for a Resource Efficient and Green Asia and the Pacific - Measuring progress of sustainable consumption and production, green economy and resource efficiency policies in the Asia-Pacific region, Schandl, H., West, J., Baynes, T., Hosking, K., Reinhardt, W., Geschke, A., Lenzen, M. United Nations Environment Programme, Bangkok.

[26] https://www.yicode.org.cn/en/chinas-2020-water-resources-bulletin-released/

(total water use, total water use per capita, and total water use intensity) were used to express the role of water use in sustainable consumption and production. Moreover, another indicator (water footprint by sectors) was used to express the water use by sectors based on the consumption footprint methodology.

The total water use of China was showing a decrease in trend from 2011 to 2020. Total water use of China decreased at the rate of 2.71 billion cubic meters per year. The decrease in total water use was noticed after 2013, which is mainly due to the decline in water use by the agricultural sector. The reason behind the decline in total water use is mainly the implementation of high efficiency irrigation systems as compared to the conventional irrigation system[27]. The time series of total water use of China from 2011 to 2020 is shown in **Figure 3-4**.

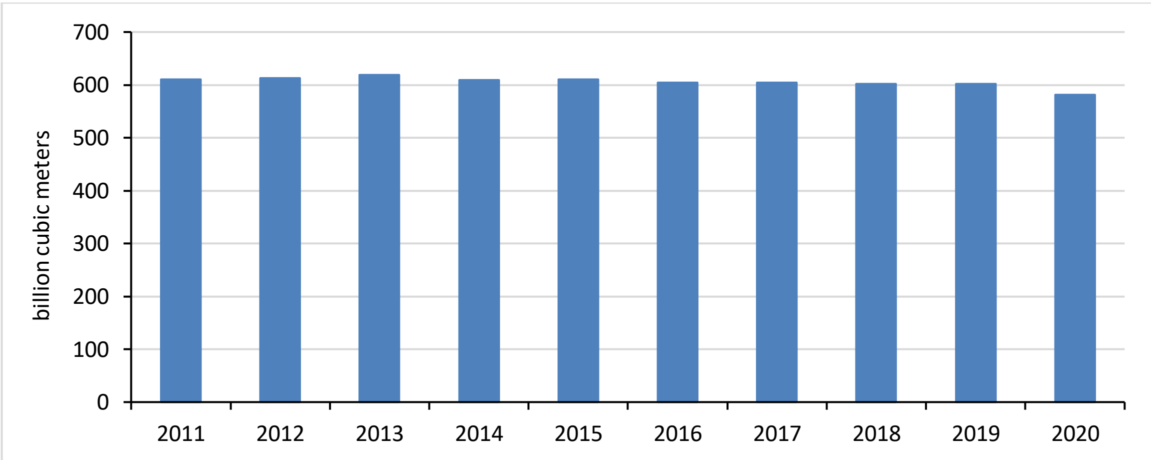

Figure 3-4 Total water use of China (China Water Resources Bulletin)

Water use per capita

The water use per capita indicator is the ratio of the total freshwater abstractions (i.e., agriculture, industry, residential, and the environmental sectors, from all sources including surface and underground and excluding the soil moisture) to the population of the country. The data was also obtained from China Water Resources Bulletin (2011-2020) for annual total water use. Population data of China was retrieved from the World Bank Database.

[27] https://www.fao.org/aquastat/statistics/query/results.html

The water use per capita of China decreased from 2011 to 2020. In terms of percentage, total water use per capita of China decreased by almost 9 percent. The decrease in water use per capita from 2011 to 2020 is mainly due to the population expansion showing a four percent increase from 2011 to 2020 (see **Figure 3-*1***), and decoupling efforts of the policymakers by using the water more efficiently, especially in the agriculture sector[28] . The time series of total water use per capita of China from 2011 to 2020 is shown in **Figure 3-5**.

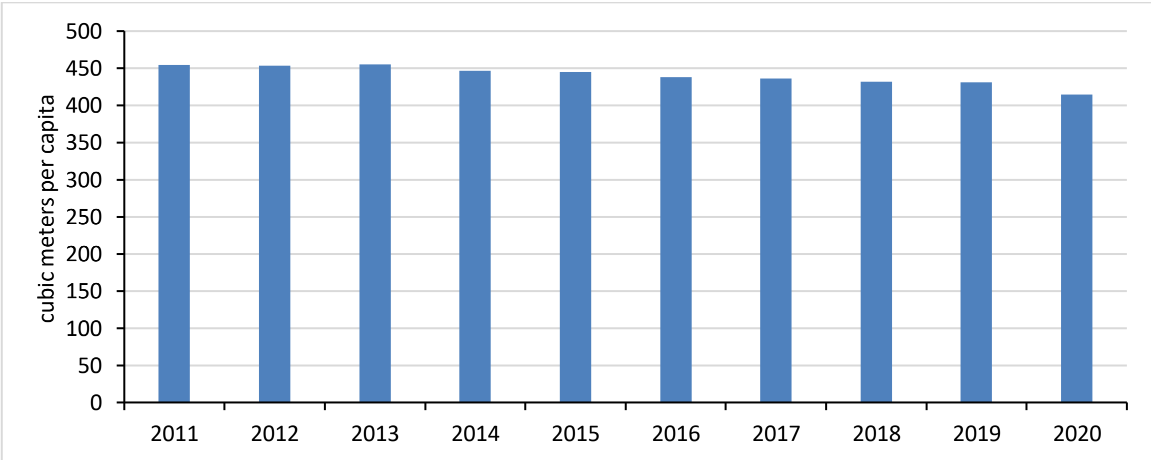

Figure 3-5 Total water use per capita of China

Water use intensity

The water use intensity is the ratio of total water use to the GDP of a country. The total water use intensity of China decreased significantly from 2011 to 2020. In 2011, the total water use intensity of China was 0.074 cubic meters per dollar. The total water use intensity of China decreased at the rate of 0.0038 cubic meters per dollar per year from 2011 to 2020. The significant decrease in the total water use intensity of China is due to the shift from an agrarian-based economy to an industrialized economy which shows almost 77 percent increase in total GDP from 2011 to 2020 (see **Figure 3-2**). In terms of percentage, total water use per capita of China decreased by almost 46 percent. Moreover, the use of high efficiency irrigation systems in the agriculture sector, and the decoupling efforts of the policymakers are among the few reasons for this change. The time series of water use intensity of China from 2011 to 2020 is shown in **Figure 3-6**.

[28] https://www.fao.org/aquastat/statistics/query/results.html

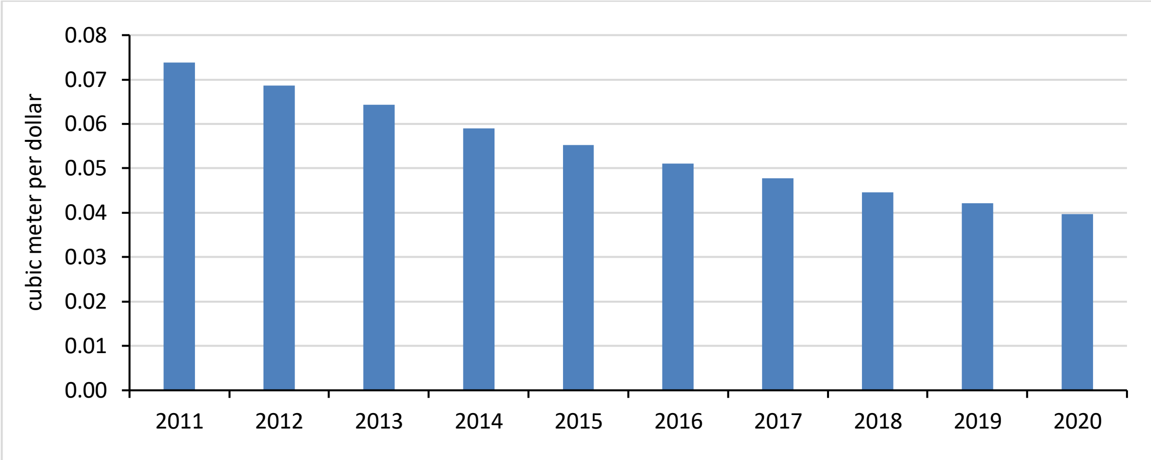

Figure 3-6 Total water use intensity of China

Water footprint

Global water extraction is linked to final demand, which includes final consumption, according to the water footprint of the consumption indicator. This means that water incorporated in a product will be accounted under the jurisdiction of its final consumption, rather than where it was initially input in the product's creation, as with the other footprint indicators. Water is the most important resource for economic output. As industrial progress is linked with GDP growth, that puts further pressure on water resources even after the decoupling efforts. To analyze the hotspot among the sectors and the regions, the SCP Hotspots Analysis Tool (SCP-HAT) provides the blue water consumption footprint of multiple sectors. This section is focusing on the water use footprint of five different sectors (i.e., agriculture, food, tourism, construction, transportation). Furthermore, in this report the hotel and restaurants sector are used as a proxy of tourism. The sectoral water use footprint at country level is taken from 2010 to 2018. The methodology of water use footprint is explained in SCP Hotspots Analysis Tool (SCP-HAT)[29].

Water footprint of agriculture sector

Water use footprint in the agriculture sector deals with the water use by food crops (e.g., wheat, maize, cereals, etc.), oil, fiber, non-perennial, spices, aromatic, drug and pharmaceutical, crops beverage crops perennial crops, plant propagation, and water use in

[29] http://scp-hat.lifecycleinitiative.org/methods/

livestock farming based on consumption footprint. The water use footprint of the agriculture sector of China was increasing from 2010 to 2018. In 2010, the water use footprint of the agriculture sector in China was 102.3 billion cubic meters. Water use footprint of the agriculture sector in China increased at the rate of 0.65 billion cubic meters per year from 2010 to 2018. In terms of percentage, it increased by 6 percent. During the same period (2010-18), land use under agriculture also increased almost by 7 percent. Therefore, the increase in water use footprint is mainly due to the increase in land use under agriculture. The time series of water use footprint of the agriculture sector of China from 2010 to 2018 is shown in **Figure 3-6**.

Water footprint of food sector

Water use footprint of food sector deals with the water used by processing, preserving, and manufacture of meat and fish-based products, cereal-based products, food crop products, mixed food and feed, cocoa, fiber-based products, chocolate and sugar confectionery, vegetable and animal oils and fats, and Manufacture of dairy products, alcoholic and other beverages, tobacco products based on consumption footprint. Water use in the food sector of China was showing an increase in trends. Water use footprint of the food sector of China increased at the rate of 0.23 billion cubic meters per year from 2010 to 2018. The water use footprint of food sector increased by 80 percent from 2010 to 2018. The increase in water use footprint of the food sector is due to the expansion in the food industry. Land use footprint of food sector also supports this hypothesis, because land use footprint of food sector increased by 45% from 2010 to 2018. The time series of water use footprint of the food sector of China from 2010 to 2018 is shown in **Figure 3-7**.

Water footprint of construction sector

Water use footprint of the construction sector is defined as the water use in construction of all buildings, roads and railways, utilities and other civil engineering activities based on consumption footprint. The water use footprint of the construction sector of China was increasing significantly from 2010 to 2018. Water use footprint of the construction sector of China increased at the rate of 0.53 billion cubic meters per year from 2010 to 2018. In terms of percentage, it increased by 84 percent from 2010 to 2018. The overall increase in water use footprint of the construction sector is mainly due to industrialization, urban expansion, and population increase (see **Figure 3-*1*** and **Figure 3-*2***). The time series of water use footprint of the construction sector of China from 2010 to 2018 is shown in **Figure 3-7**.

Water footprint of tourism sector

Water use footprint of the tourism sector is defined as the water use in hotels and restaurants for accommodation and food service activities based on consumption footprint[30]. The water use footprint of the tourism sector of China exhibited an oscillating trend from 2010 to 2018. However, in 2010, the water use in the tourism sector in China was 1.59 billion cubic meters per year. In terms of percentage, it increased by 16 percent from 2010 to 2018. In the first four years (2010-2014), it increased from 1.59 to 1.88 billion cubic meters. The increase in water use footprint of the tourism sector from 2010 to 2014 is more likely due to the revival of economic activities after the depression in economies in 2009. From 2014 onwards, a gradual decrease in trends was observed. It is possibly due to the application of better water management policies or using the more efficient use of water in the tourism sector by promoting ecotourism in China[31]. The time series of water use footprint of the tourism sector of China from 2010 to 2018 is shown in **Figure 3-7**.

Water footprint of transport sector

Water use footprint of the transport sector is defined as the water use in land transport, water transport, air transport, transport via pipeline, warehousing and support activities for transportation based on consumption footprint. The water use footprint of the transport sector of China increased from 2010 to 2018 at a rate of 0.017 billion cubic meters per year. In terms of percentage, it increased by 38 percent from 2010 to 2018. The increase in water use footprint of the transport sector of China is most probably due to the increase in economic development which triggers the transportation activities as well. The time series of water use footprint of the transport sector of China from 2010 to 2018 is shown in **Figure 3-7**.

[30] SCP-HAT (http://scp-hat.lifecycleinitiative.org/module-2-scp-hotspots/)
[31] Li, Y., Zhang, L., Gao, Y., Huang, Z., Cui, L., Liu, S., Fang, Y., Ren, G., Fornacca, D. and Xiao, W. (2019). *Ecotourism in China, Misuse or Genuine Development? An Analysis Based on Map Browser Results. Sustainability, 11(18), 4997–.* doi:10.3390/su11184997.

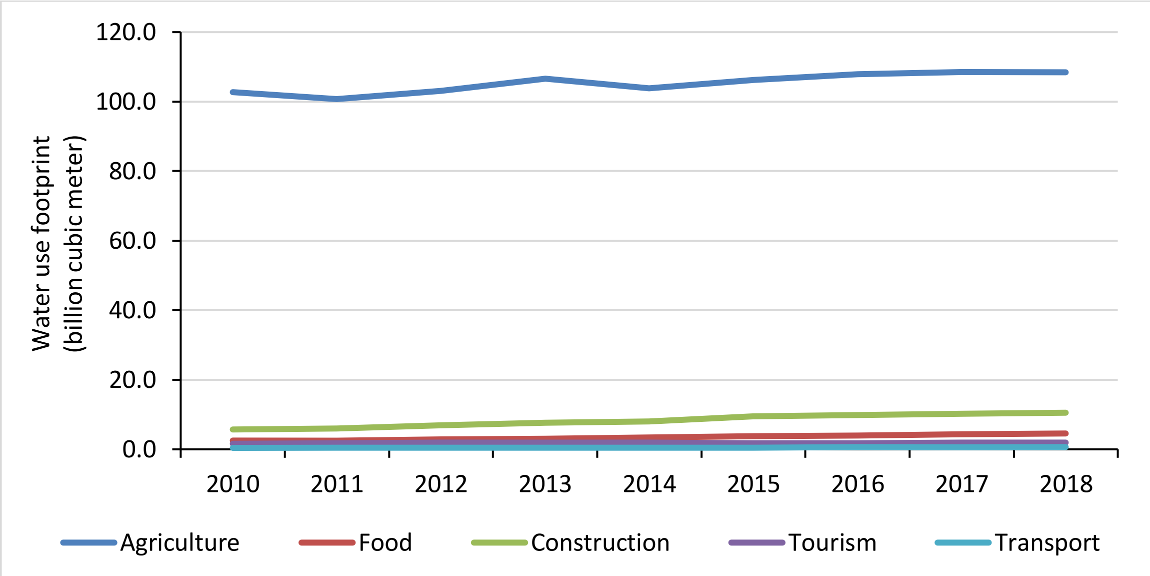

Figure 3-7 Water use footprint of five different sectors of China

3.1.1.2 Land use

Human progress has developed at an ever-increasing rate in modern history. As a result, there have been extraordinary shifts in land use.[32]. The change in different land-use types is driven by growth in population, GDP, food requirements, etc.[33]. total land use of the country and land use per capita was used as indicator of land as natural resource use. The land use data was downloaded from European Space Agency [34] from 1992 to 2015 and processed in ArcGIS.

<u>**Total land use**</u>

The total land use of China slightly increased during 1992 to 2015 at the rate of 0.48 million hectares per year. In terms of percentage, total land use of China increased by almost 2 percent. The increase in total land use of China is mainly due to the rapid increase in industrialization, robust urbanization, and expansion in agricultural land use. The abrupt increase in land use in the construction sector of China (**Figure 3-8**) also supports the argument of urbanization. Both factors urbanization and industrialization are driven by

[32] Roser M (2014) Human development index (HDI)Published online at OurWorldInData.org. Retrieved from: http://ourworldindata.org/human-development-index (Accessed 27 December 2021)
[33] Zhao, S., Peng, C., Jiang, H., Tian, D., Lei, X., and Zhou, X. (2006). Land use change in Asia and the ecological consequences. Ecological Research, 21(6), 890–896. doi:10.1007/s11284-006-0048-2
[34] http://maps.elie.ucl.ac.be/CCI/viewer/download.php

upsurge in population and rise in financial condition of Chinese. The time series of total land use of China from 1992 to 2015 is shown in **Figure 3-8**.

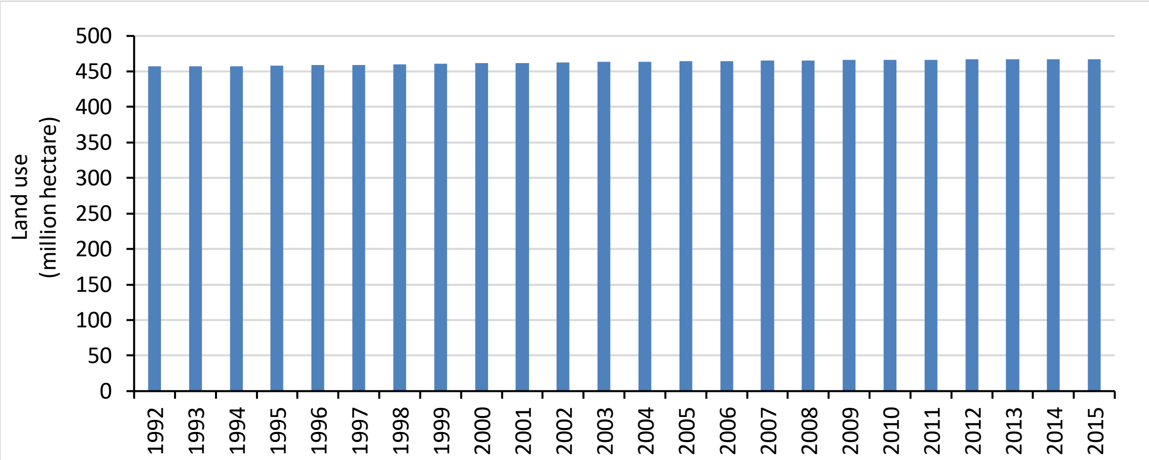

Figure 3-8 Total land use of China

Total land use per capita

The total land use per capita of China decreased between 1992 to 2015 at the rate of 0.0021 square meters per capita per year. The decrease in total land use per capita of China is probably due to increase in population by almost 18 percent from 1992 to 2015, while the land resources were almost the same as it was in 1992. The time series of total land use per capita and the total population of China from 1992 to 2015 is shown in **Figure 3-9**.

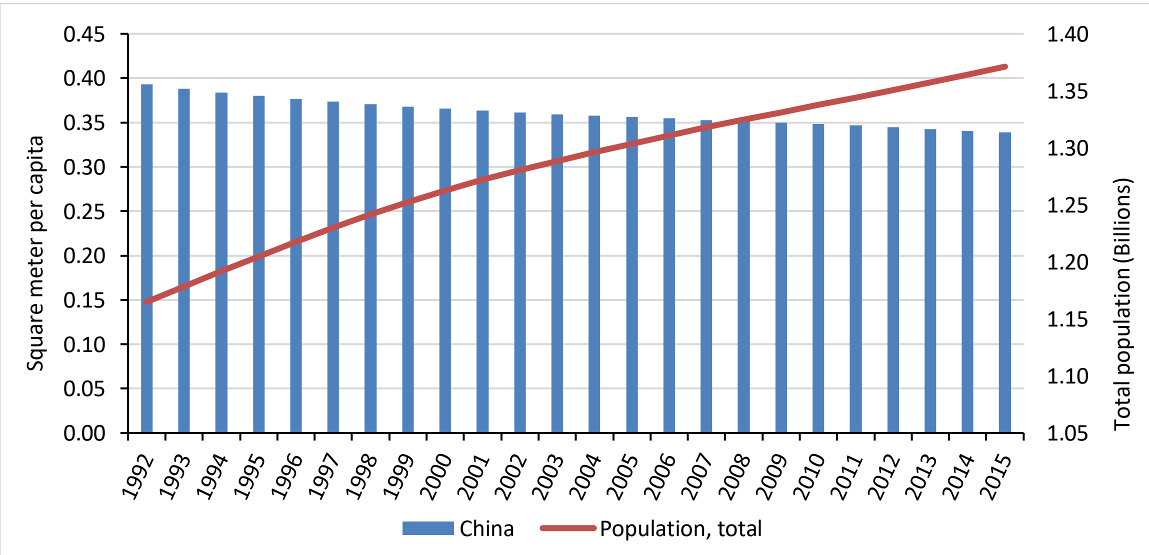

Figure 3-9 Total land use per capita of China

Land use intensity

The total land use intensity of China decreased significantly from 1992 to 2015. In 1992, the total land use intensity of China was 10.71 square meter per dollar annually. Overall, it decreased with the rate of 0.39 square meters per dollar from 1992 to 2015. The significant decrease in the total land use intensity of China is probably due to the rapid industrialization and robust urbanization as a result total GDP increased by nearly eight times in 2015, as compared to the GDP of 1992. The time series of total land use intensity of China from 1992 to 2015 is shown in **Figure 3-10**.

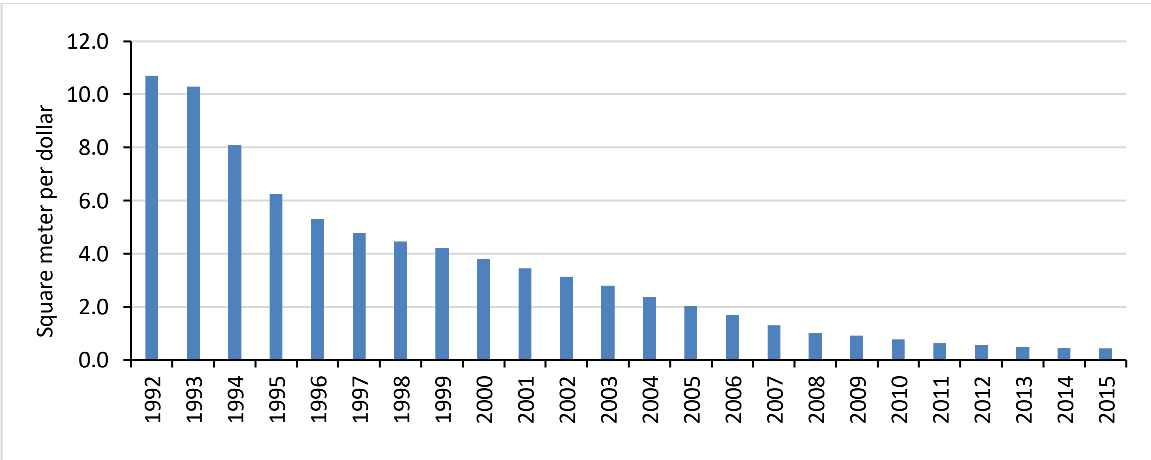

Figure 3-10 Total land use intensity of China

Land footprint

As industrial progress is linked with GDP growth, that puts further pressure on land resources across the globe. To analyze the hotspot among the sectors and the regions, the SCP Hotspots Analysis Tool (SCP-HAT) provides the land use consumption footprint of multiple sectors. This section is focusing on land use footprint of five different sectors (agriculture, food, tourism, construction, transportation). Furthermore, in this report the hotel and restaurants sector is used as a proxy of tourism. The sectoral water use footprint at country level is taken from 2010 to 2018. The methodology of land use footprint is explained in detailed in the SCP

Hotspots Analysis Tool (SCP-HAT)[35]. However, "land use footprint of a sector" is not the same as "land use of a sector".

Land footprint in agriculture sector

Land use footprint of agriculture sector deals with the land used for the cultivation of food crops (e.g., wheat, maize, cereals, etc.), oil, fiber, non-perennial, spices, aromatic, drug and pharmaceutical, crop beverage crops perennial crops, plant propagation, and land use in livestock farming based on consumption footprint. Land use footprint of the agriculture sector in China increased from 1990 to 2018. In 1990 the land use of the agriculture sector in China was 409.7 million hectares. Land use footprint of the agriculture sector of China increased at the rate of 1.08 million hectares per year from 2010 to 2018. The rapid increase in land use footprint of the agriculture sector is possibly due to the rapid increase in economic progress and technological advancement and population expansion. The time series of land use footprint of the agriculture sector of China from 1990 to 2018 is shown in **Figure 3-11**.

Land footprint in food sector

Land use footprint of agriculture sector deals with the land used for the cultivation of food crops (wheat, maize, cereals, etc.), oil, fiber, non-perennial, spices, aromatic, drug and pharmaceutical, crop beverage crops perennial crops, plant propagation, and land use in livestock farming based on consumption footprint. Land use footprint of the agriculture sector in China increased from 1990 to 2018. In 1990 the land use of the agriculture sector in China was 409.7 million hectares. Land use footprint of the agriculture sector of China increased at the rate of 1.08 million hectares per year from 2010 to 2018. The rapid increase in land use footprint of the agriculture sector is possibly due to the rapid increase in economic progress and technological advancement and population expansion. The time series of land use footprint of the agriculture sector of China from 1990 to 2018 is shown in **Figure 3-11**.

[35] http://scp-hat.lifecycleinitiative.org/methods/

Land use footprint in food sector

Land use footprint of food sector deals with the land use for processing, preserving, and manufacture of meat and fish-based products, cereal-based products, food crop products, mixed food and feed, cocoa, fiber-based products, chocolate and sugar confectionery, vegetable and animal oils and fats, and Manufacture of dairy products, alcoholic and other beverages, tobacco products based on consumption footprint. Land use footprint of the food sector of China was showing increasing trends from 1990 to 2018. In 1990 the land use of the food sector in China was 126.23 million hectares. Land use footprint of the food sector of China increased at the rate of 4.1 million hectares per year from 2010 to 2018. The increase in land use footprint of the food sector is possibly due to industrialization, especially due to the expansion of the food industry[36]. The time series of land use footprint of the food sector of China from 1990 to 2018 is shown in **Figure 3-11**.

Land footprint in construction sector

Land use footprint of construction sector is defined as the land use in construction of all buildings, roads and railways, utilities and other civil engineering activities based on consumption footprint[37]. Land use footprint of the construction sector of China was showing an increasing trend, especially in the late 2010s. In 1990 the land use footprint of the construction sector in China was 5.87 million hectares. Land use footprint of the construction sector of China increased at the rate of 2.9 million hectares per year from 2010 to 2018. The rapid increase in land use footprint of the construction sector is probably due to the rapid increase in industrial development, improvement in transportation infrastructure (road, railways, etc.) and urbanization. However, a decline was noticed in 2012, the decrease in investments in rail infrastructure, railroad rolling stock, and length of rail network[38,39]. The combined decrease in these three sectors is probably causing the decline in land use footprint of the construction sector in 2012. The time series of land use footprint of the construction sector of China land from 1990 to 2018 is shown in **Figure 3-11**.

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[36] http://www.news.cn/english/2021-12/18/c_1310380439.htm
[37] SCP-HAT (http://scp-hat.lifecycleinitiative.org/module-2-scp-hotspots/)
[38] https://www.statista.com/statistics/276290/china-railways-train-fleet-by-type-of-carriage/
[39] https://www.statista.com/statistics/224582/length-of-rail-network-in-china-by-province/

Land footprint in transport sector

Land use footprint of the transport sector is defined as the land use in land transport, water transport, air transport, transport via pipeline, warehousing and support activities for transportation based on consumption footprint. Land use footprint of the transport sector in China increased significantly, especially in the first decade of this century. Land use in the transport sector of China increased at the rate of 0.95 million hectares per year from 2010 to 2018. The increase in land use footprint of the transport sector is possibly due to the rapid improvement in transportation means. The time series of land use in the transport sector of China from 1990 to 2018 is shown in **Figure 3-11**.

Land footprint in tourism sector

Land use footprint of the tourism sector is defined as the land use in hotels and restaurants for accommodation and food service activities based on consumption footprint. Land use footprint in the tourism sector in China increased significantly from 3.31 to 7.91 million hectares from 1990 to 2018. It decreased sharply in the late 2010s probably due to the economic depression in 2009. The rise in land use footprint in the tourism sector is probably due to the increase in the contribution of tourism in economic development and population increase. Tourism sector positively correlated with gross domestic products and population size[40]. The time series of land use footprint in the tourism sector of China from 1990 to 2018 is shown in **Figure 3-11**.

[40] Li, Y., Zhang, L., Gao, Y., Huang, Z., Cui, L., Liu, S., Fang, Y., Ren, G., Fornacca, D. and Xiao, W. (2019). Ecotourism in China, Misuse or Genuine Development? An Analysis Based on Map Browser Results. Sustainability, 11(18), 4997–. doi:10.3390/su11184997

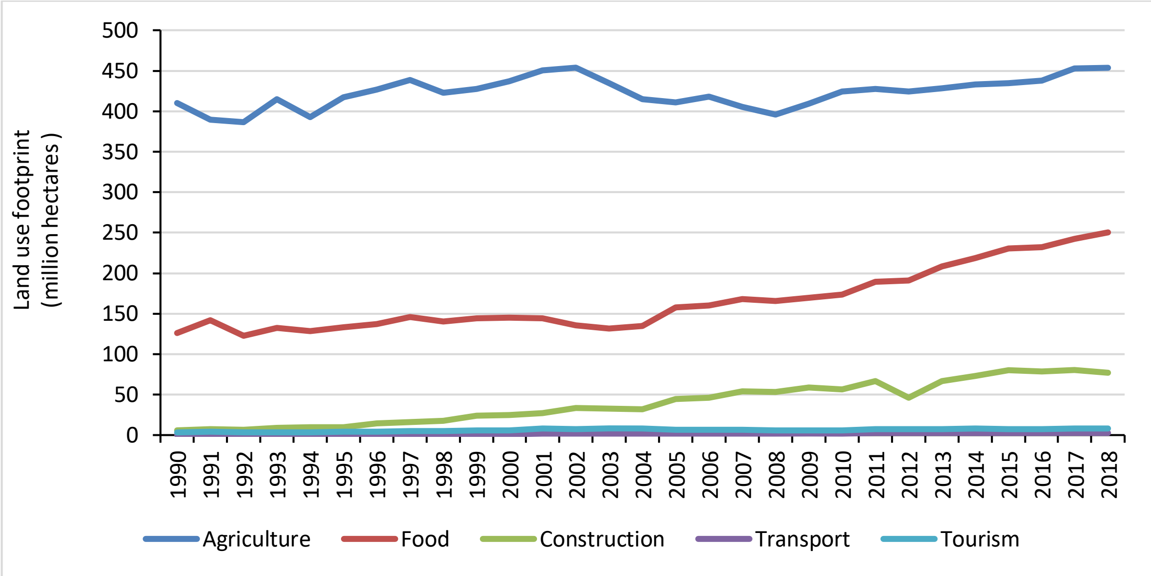


Figure 3-11 Land use footprint of five different sectors of China

3.1.1.3 Material use

The total domestic material consumption (DMC, tonnes) and domestic material consumption per capita (DMC per capita, tonnes per capita) are used as indicators to measure the material use. Further, the material use is classified into four main material categories and 13 subcategories as shown in **Table 3-1**. The time series here covers the period 2010 to 2017.

Table 3-1 The four categories of materials included in domestic material consumption, with decomposition into 13 subcategories (CSIRO, 2018; Li et al., 2015)

Main material categories	Thirteen subcategories
Biomass	Crops Crops residue Wood Animal products Grazed biomass Fodder crops
Fossil fuels	Coal Petroleum

Main material categories	**Thirteen subcategories**
	Natural gas
Metal ores	Ferrous ores Non-ferrous ores
Non-metallic minerals	Industrial minerals Construction minerals

Source: CSIRO[41] (2018) and Li (2015)[42]

Figure 3-12 shows the DMC of China from 2010 to 2017. As presented in **Figure 3-12**, the total DMC in China has increased from around 26 billion tonnes to more than 35 billion tonnes in just seven years. During the concerned duration (2010-2017) the DMC in the country showed a continuously increasing trend. The overall increase in the country's DMC was 34%. The reason behind this increase in DMC of the country can be the enhanced economic activities that caused a tremendous increase in countries gross domestic product (GDP) to more than USD 12 billion in 2017 from USD 6 billion in 2010. From 2010 to 2017, the overall increase in country's GDP was 102%. Another reason possibly due to the increase in population. The country's population increased with a rate of 3.6% and reached to around 1.4 billion in 2017 from 1.3 million in 2010.

[41] CSIRO (2018). Technical annex for Global Material Flows Database. UN Environment Programme. Available at https://www.csiro.au/~/media/LWF/Files/CES-Material-Flows_db/Technical-annex-for-Global-Material-Flows-Database.pdf

[42] Li, N., Zhang, T., Qi,J., & Huang,Y. (2015). Using Multiple Tools to Analyze Resource Exchange in China. Sustainability, 7, 12372-12385. https://doi.org/10.3390/su70912372

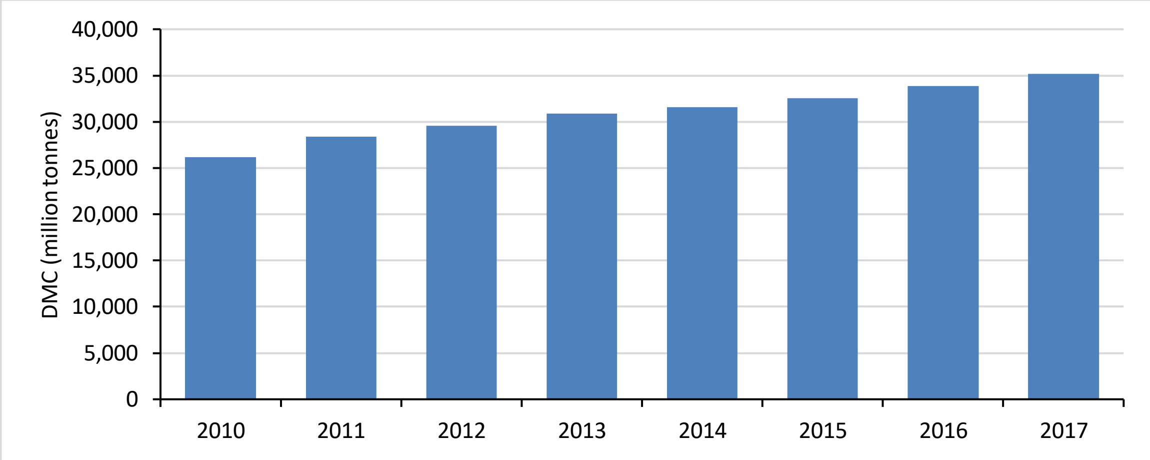


Figure 3-12 Domestic material consumption in China (2010 – 2017)

Figure 3-13 shows the per capita DMC of China, Asia, and the World from 2010 to 2017. In 2010 the country's per capita DMC was 19.26 tonnes per capita which was increased with a rate of 30% and reached to 24.97 tonnes per capita. It can be seen from **Figure 3-12** and **Figure 3-13** that the country's total DMC and per capita DMC both increased throughout the concerned time period. Moreover, the country's per capita DMC is almost two folds as compared to the per capita DMC in Asia and the World. This shows that there is huge need to introduce more sustainable consumption and production systems in the country to divert China's economy from material intensive to material efficient economy. To do so, technologically advanced manufacturing techniques should be adopted to achieve precision in the manufacturing process which can end up in reduction of the amount of material required as well as lower the risk of wastage. Moreover, advanced manufacturing techniques may ensure the quality standards of the end products that are supplied to the consumer.[43]

[43] https://businesscasestudies.co.uk/how-technology-plays-a-key-role-in-the-manufacturing-industry/#:~:text=Technology%20also%20plays%20a%20key,precision%20in%20the%20manufacturing%20process.&text=It%20reduces%20the%20risk%20of,products%20are%20supplied%20to%20consumers.

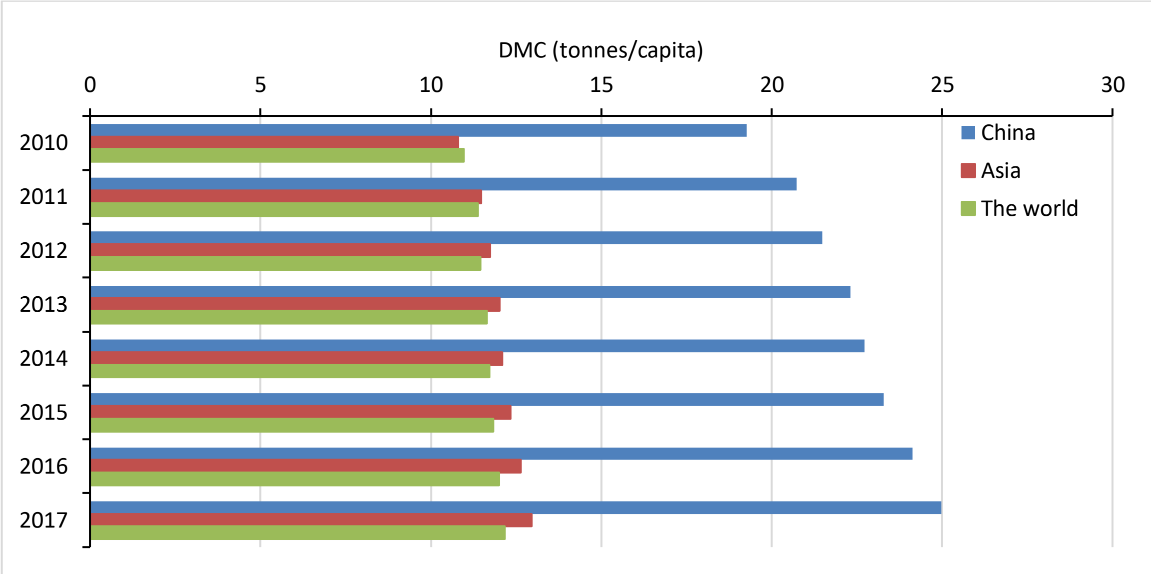


Figure 3-13 Per capita domestic material consumption in China, Asia, and the World during 2010-2017

Figure 3-14 presents the category-wise DMC in China. It can be seen that all material categories exhibited increasing trajectories. However, some material categories showed a tremendous increase while others increased as business as usual. From 2010 to 2017, the average annual growth in DMC of biomass, fossil fuels, metal ores, and non-metal minerals has increased at a rate of 0.020%, 0.025%, 0.065%, and 0.039%, respectively. It can be observed that the percentage growth in metal ores consumption is highest among all four material categories, followed by non-metal minerals. The overall total annual DMC of biomass, fossil fuels, metal ores, and non-metallic minerals has increased with a rate 17%, 22%, 68% and, 37% in 2017 from 2010, respectively. These statistics depict increasing trend of urbanization, especially rising numbers of skyscrapers in the country.

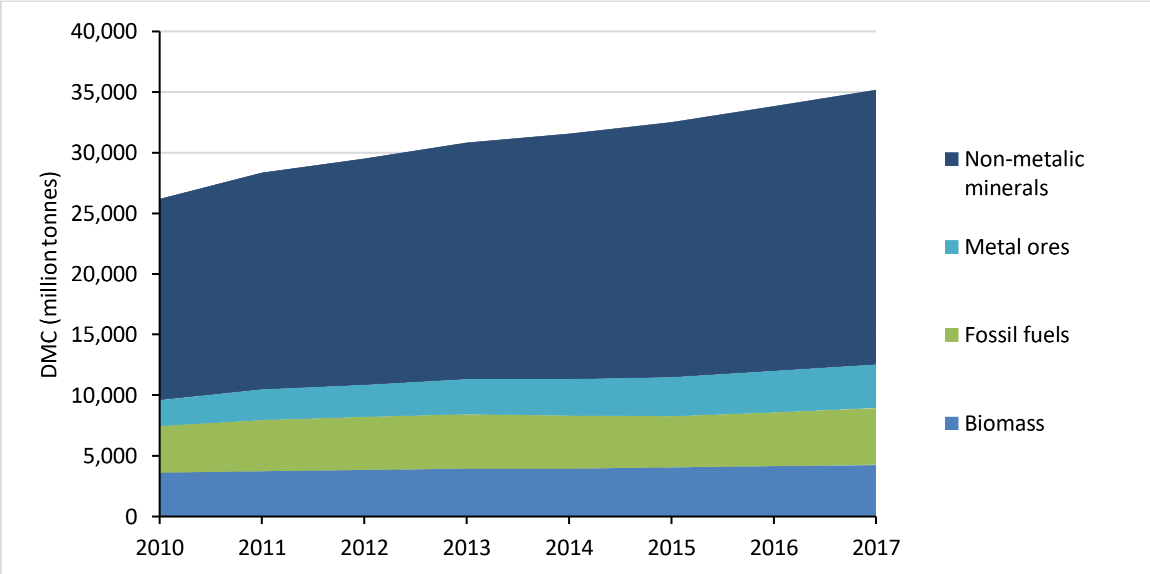


Figure 3-14 Domestic material consumption by material category in China (2010 – 2017)

Material use by major sectors

Natural resources are natural sources of matter and energy that humans can employ as raw materials in production and consumption under certain technological, economic, and social conditions.[44] China has surpassed the rest of the world in terms of material consumption, putting enormous strain on the environment, but it has also remained one of the most successful country in terms of resource efficiency.[45] **Figure 3-15** shows the material use in six major sectors in China.

[44] https://www.tandfonline.com/doi/abs/10.2753/CES1097-147529015?journalCode=mces19
[45] https://www.unep.org/news-and-stories/press-release/china-outpacing-rest-world-natural-resource-use

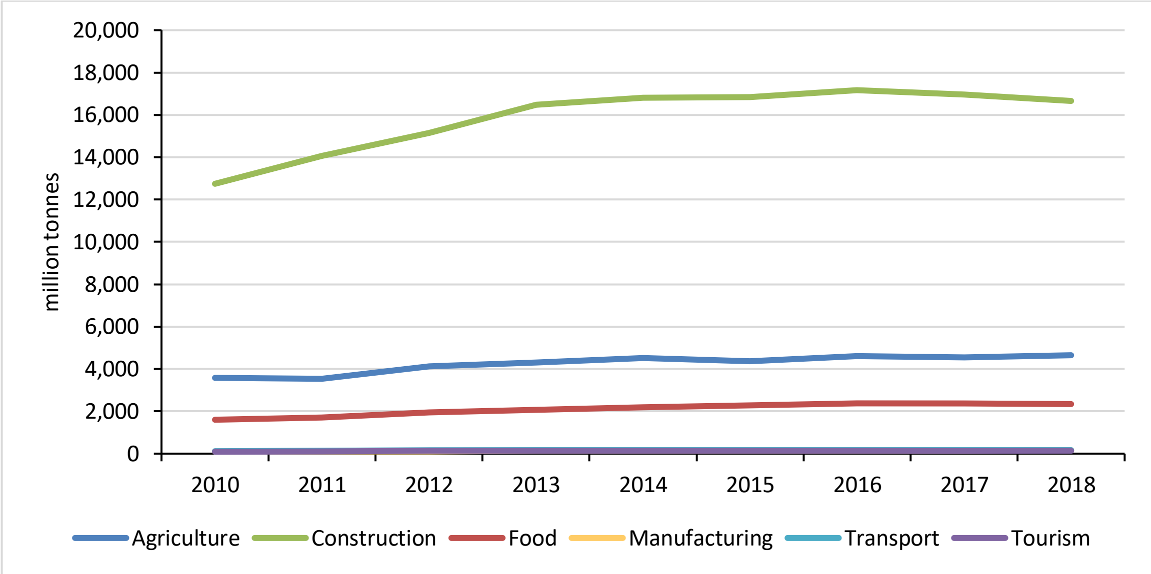


Figure 3-15 Sector-wise material footprint in China (2010-2018)

It can be seen from **Figure 3-15** that the construction sector has the highest material consumption though the sector has experienced some ups and downs during the considered time series. From 2010 to 2016, the material consumption in construction sector continuously increased and reached at 17.2 billion tonnes from 12.7 billion tonnes, afterwards it experienced a minor decline of 3% and reached to around 16.6 billion tonnes in 2018. On the other hand, agriculture sector is the second largest sector in the country regarding material consumption. The material consumption of agriculture sector was around 3.6 billion tonnes in 2010 that has increased with a rate of 29% and reach to more than 4.6 billion tonnes in 2018. The third largest sector regarding material consumption is food sector in the country, while the percentage growth of material consumption in food sector was 47%, higher as compared to agriculture sector in the country. The sectors including manufacturing, transport, and tourism are the bottom three sectors, respectively. However, the percentage growth in material consumption of manufacturing sector was 57% i.e., the highest among all six concerned sectors during 2010 to 2018.

Material intensity

Material intensity refers to the amount of material (in physical mass terms) used to produce one unit of GDP (in monetary terms). In other words, material intensity is simply the inverse of material productivity. These two terms are often misunderstood as simply consuming less which results in the loss of economic and social gains that can be obtained from resource use. In this report, the material intensity indicator is defined as the domestic material consumption per unit of gross domestic product (DMC per GDP). In this section of the report, material intensity of China is presented. The data for the domestic material consumption and gross domestic product (GDP) is sourced from the UNDP (UNEP, 2021). The time series here covers the period from 2010 to 2017.

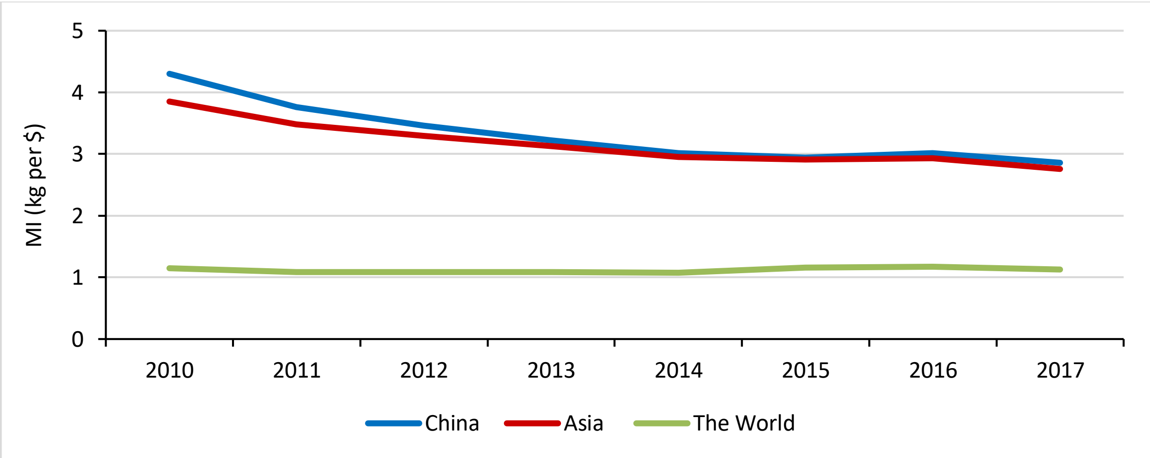


Figure 3-16 Material intensity for China, Asia, and the World (2010 – 2017)

Figure 3-16 exhibits the comparison of material intensity (kg per $) between China, Asia, and the world. The material intensity of the world remained almost constant during 2010-2017. On the other hand, there was a tremendous improvement in the material intensity of China and overall, around the Asian region. The amount of material to produce one US$ in terms of GDP has decreased by around 34% and 29% in China and overall Asian region from 2010 to 2017, respectively. In spite of this huge improvement, the material intensity of China and the overall Asian region is still 2.5 times and 2.4 times higher than the overall world's material intensity, respectively. One of the reasons behind this passiveness of the Asian region in terms of material intensity can be Asia's position of the biggest manufacturer in the world. Another reason is the consumption of natural resources in conventional ways. It shows that the Asia Pacific developing region still has to go a long way to attain the material intensity to compete with the industrialized world. This can be done by adopting innovative urban development, advanced modes of transportation, efficient energy production and modern economic structure.

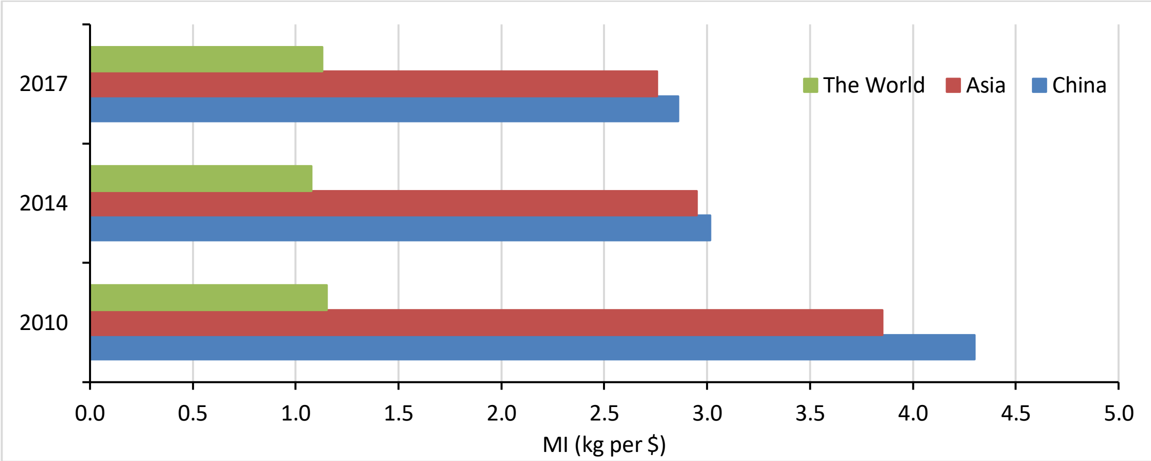


Figure 3-17 Material intensity of China, Asia, and the World (2010, 2014, 2017)

Figure 3-17 compares the material intensity of China with the material intensity of Asia as well as the whole world. It can be seen that China's material intensity was lower as compared to the overall Asia in 2010. Despite of a prominent fall in the country's material intensity, it still remained higher as compared to the overall Asian region in 2014 and 2017. The external reason behind this gap in material efficiency of China and the Asian region may be the adoption of more efficient production systems and technological development in industrial Asian countries (Singapore, Korea, Japan, etc.). The internal reason may be the highly consumer centric lifestyle of the people in the country. For instance, China's consumer market is the second largest in the world after the United States of America (USA).[46] On the other hand, material intensity of China as well as overall Asian region remained higher when compared to overall World's material intensity during the previous decade.

Material footprint of consumption

Figure 3-18 shows the material footprint of consumption of China. It can be seen that the material footprint of consumption has continuously increased in China. The country as a

[46] https://www.mazars.co.th/Home/Services/International-services/Doing-business-in-Asia-Pacific/Chinese-consumers-in-2021/Chinese-consumers-in-2021

whole accounted for 30% of the total global MF by 2010.[47] In 2010, the total material footprint of China was around 22 billion tonnes that was increased with a rate of 35% and reached to a total of more than 29 billion tonnes in 2017. This rapid growth in China's material footprint of consumption also reflects the immense growth of GDP in the country. In 2010 the total GDP of China was more than $US 6000 billion that was increased with a rate of 102% in 2017 and reached to a total of more than $US 12000 billion. The key reason to increase in both material footprint of consumption and GDP of China is capital investment. Investment in the country is primarily devoted toward real estate development in wealthier provinces along the eastern coast, as well as infrastructure (such as roads and railroads) in lower-income provinces in the far west and north (provinces such as Qinghai, Xinjiang, and Inner Mongolia).[48]

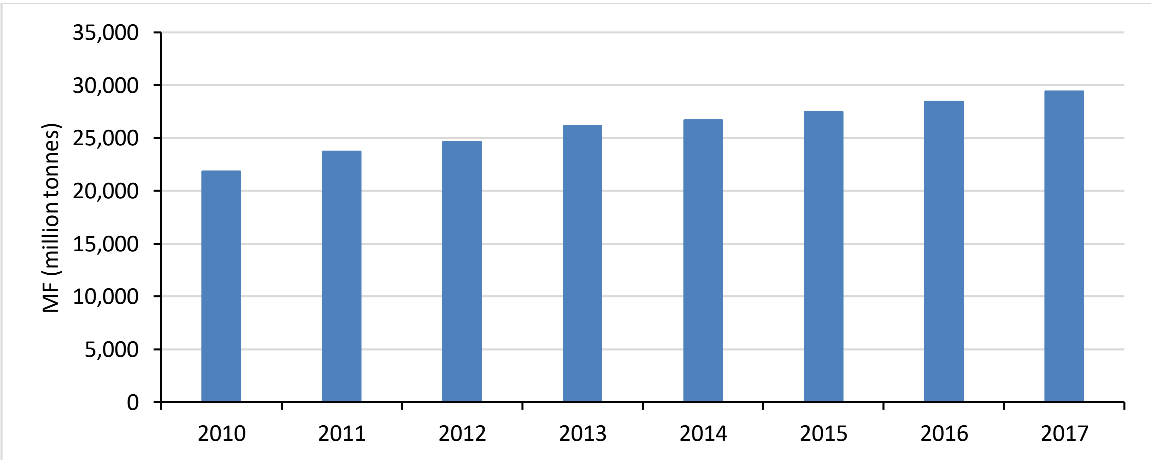


Figure 3-18 Material footprint of consumption in China (2010 – 2017)

The DMC is associated to large extraction and significant manufacturing activities while material footprint represents the material consumption for the production systems. It can be seen from **Figure 3-19** that China DMC per capita remained higher as compared to material footprint per capita from 2010 to 2017. This is because the country has been the largest exporter of goods in the world since 2009. In 2013, China became the largest trading nation

[47] https://www.nature.com/articles/s41563-019-0599-6#:~:text=A%2010%25%20increase%20in%20gross,6%25%20growth%20in%20materials%20footprint.
[48] https://www.nature.com/articles/s41563-019-0599-6#:~:text=A%2010%25%20increase%20in%20gross,6%25%20growth%20in%20materials%20footprint.

in the world. Previously, the United States held that position. According to official figures, the country's total exports in 2019 was $US 2.641 trillion.[49]

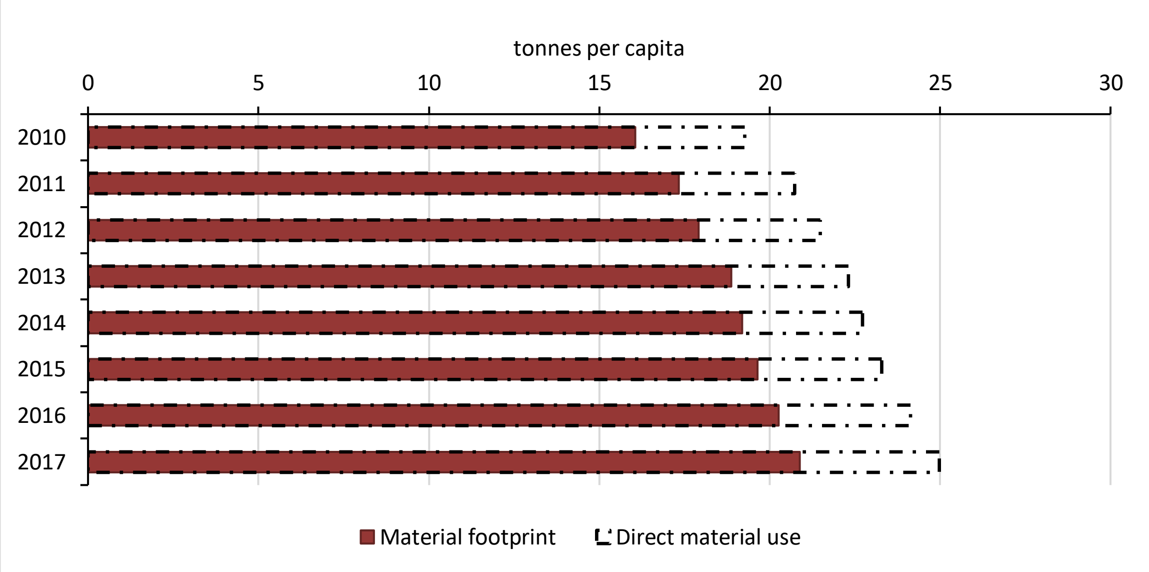


Figure 3-19 Material footprint per capita compared to domestic material consumption per capita in China (2010-2017)

Wynn Resorts Holdings
The Goldleaf sustainability program of Wynn Macau is improving the sustainable luxury through intelligent management of food, avoiding single use plastic, using clean energy, reducing energy consumption, waste reduction, and GHG reduction. The intention of implementing sustainability practices is based on its commitment to sustainability built on core principles. These practices have resulted in food management, energy saving, resource use efficiency, cost reduction, and a good reputation. Giving the best experience of responsible luxury and environmentally friendly experience to customers with full enjoyment is the goal. These luxury experience goals are to be implemented all over Wynn especially at the guest standpoint as it is the main concern for Wynn. Some of the social impacts of the newly adopted sustainable design practice at Wynn are mitigation of single-use plastic, recycling of about 930,000 kg of waste in 2019; an 80%

[49] https://www.investopedia.com/ask/answers/011915/what-country-worlds-largest-exporter-goods.asp

increase from the amount of waste recycled in 2017. Food waste was reduced by more than 280 tonnes in 2019. Water consumption was reduced from 2.7 m^3 per guest night in 2018 to 2.6 m^3 per guest night in 2019. Additionally, energy consumption was reduced from 440 kWh per m^2 in 2017 to 420 kWh per m^2 in 2019. Furthermore, greenhouse gas emissions were reduced from 273,010 tonne CO_2eq in 2017 to 253,375 tonne CO_2eq in 2019.

These social impacts were successfully achieved as a result of the implementation of "Food management through Artificial intelligence through innovative design" and "Wynn's Own Premium Bottled Water".

3.1.1.4 Energy use

Due to the rapid economic growth, the energy needs of China have dramatically increased over the past few decades, and it is expected that energy use will be increased by 60% until 2030.[50] The following indicators 'Total installed renewable capacity', 'Installed renewable capacity per capita' and 'sectoral share in total final energy consumption' were considered to evaluate the energy production and consumption patterns in the selected countries. The data, for these indicators, was retrieved from the International Renewable Energy Agency (IRENA)[51], the UN Environment Programme (UNEP) databank[52], and International Energy Agency (IEA)[53] respectively. The IEA and UNEP data was available until 2019, however, to analyze the situation amid pandemic, more updated data was required.

China's energy use is concentrated in the industry, residential, and transport sectors, which were responsible for maximum consumption of the total final energy as shown in **Figure 3-20**. Therefore, the highest energy consuming sectors have been targeted by the government (i.e., industry, residential, and transport) to increase the renewable energy share. The

[50] IRENA. 2014. RENEWABLE ENERGY PROSPECTS: China. An executive summary of the REmap 2030 report. Available at: https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2014/Nov/IRENA_REmap_China_summary_2014_EN.ashx?la=en&hash=807F1019E27CA5C3D36FBA445EC48F150D58A6B5

[51] IRENA (2022).RENEWABLE CAPACITY STATISTICS 2022. *The International Renewable Energy Agency (IRENA)*. Available at: https://www.irena.org/IRENADocuments/Statistical_Profiles/Asia/China_Asia_RE_SP.pdf. [Accessed on April 2022]

[52] UNEP. (2022). The United Nations Environment Programme. Available at: https://wesr.unep.org/downloader.

[53] IEA. (2022). International Energy Agency. Retrieved from https://www.iea.org/data-and-statistics/data-browser?country=WORLD&fuel=Energy%20consumption&indicator=TFCShareBySector.

percentage energy use in industrial, residential, and transportation sector has significantly changed since 2000. However, the energy consumption patterns almost remained same in commercial and public, agriculture/forestry and other sectors.

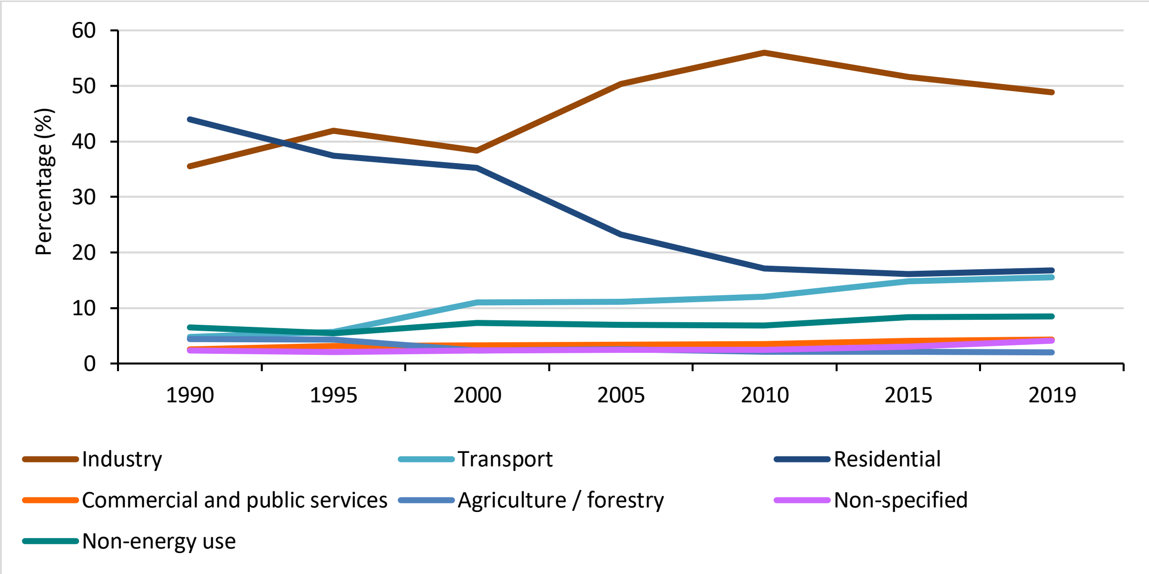
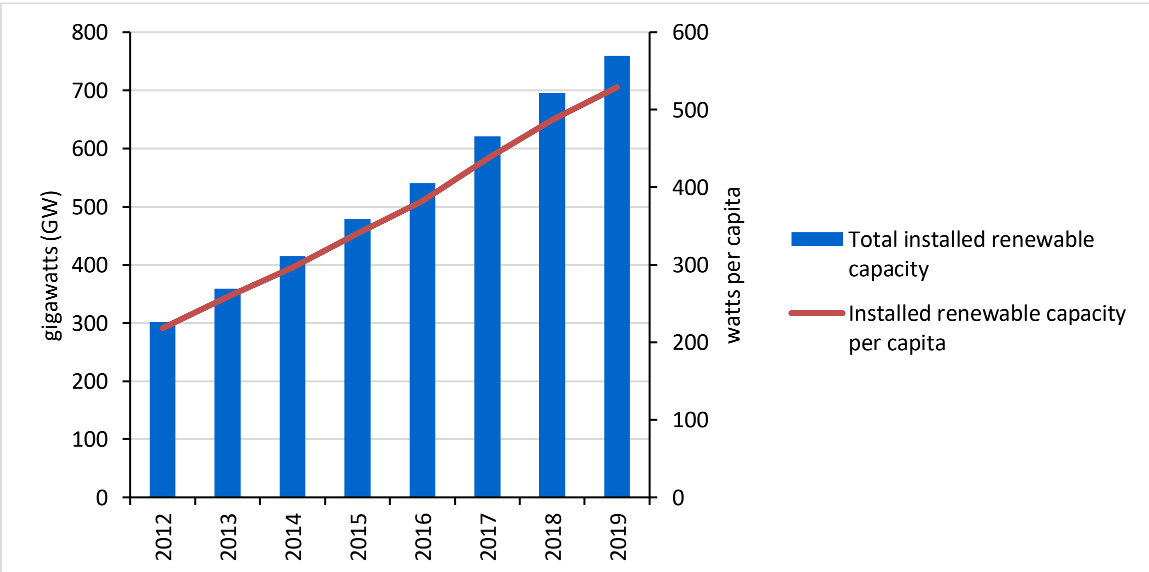


Figure 3-20 Sectoral share in total final energy consumption in China (1990-2019)[54]



[54] IEA. (2022). International Energy Agency. Retrieved from https://www.iea.org/data-and-statistics/data-browser?country=WORLD&fuel=Energy%20consumption&indicator=TFCShareBySector

Figure 3-21 Installed renewable electricity-generating capacity in China (2012-2019)[55,56]

During the 2012 to 2019, the total installed renewable energy capacity of the country has been increased substantially (i.e., almost 300 gigawatts in 2012 to 758 gigawatts in 2019) as shown in **Figure 3-21**. The main drivers of this tremendous energy transition are the improved energy security, increased air quality and enhancing cost-competitiveness of renewable technologies.

In 2020, China not only led the global markets in terms of cumulative renewable energy capacity (i.e., 908 GW) — followed by the United States, Brazil, India and Germany — but also in terms of renewable energy investment (i.e., USD 83.6 billion accounting for almost 28% of the global total) which was actually 12% lower than the previous year investments[57]. Out of which 66% were invested in the onshore and offshore wind sector, 30% in solar PV, 4% in biomass and waste and 0.5% in mini hydropower projects. On the other hand, in 2020, some financial incentives have also been reduced for renewables in China. The public funding has been completely ended for new offshore wind farms and the budget is halved (i.e., USD 460 million to USD 230 million) for subsidizing the new solar power; furthermore, China planned to phase out the feed-in tariffs for solar PV since 2021[58]. The policymakers are focusing on overcoming persistent challenges that prevent the efficient integration of renewable energy. The curtailment rate - the percentage of renewable energy that might have been produced but was rejected by the grid - is an area of concern. Furthermore, the overbuilding of wind and solar in distant areas with inadequate transmission is another issue. On the hand, the pandemic was also considered as one of the drivers of taken measures to reduce the strain in national budget.

However, in the past few decades, China energy policy has shown a significant transition towards the renewables — and reached the renewable energy's share in power generation

[55] UNEP. (2022). The United Nations Environment Programme. Available at: https://wesr.unep.org/downloader
[56] IRENA (2022).RENEWABLE CAPACITY STATISTICS 2022. *The International Renewable Energy Agency (IRENA)*. Available at: https://www.irena.org/IRENADocuments/Statistical_Profiles/Asia/China_Asia_RE_SP.pdf. [Accessed on April 2022]
[57] REN21. 2021. Trends in China Facts from the Renewables 2021 Global Status Report. Available at: https://www.ren21.net/wp-content/uploads/2019/05/REN21_GSR2021_Factsheet_China_EN.pdf
[58] REN21. 2021. Trends in China Facts from the Renewables 2021 Global Status Report. Available at: https://www.ren21.net/wp-content/uploads/2019/05/REN21_GSR2021_Factsheet_China_EN.pdf

at 38.1% until 2017 — but it is still needed to continue encouraging the renewable energy to promote the sustainable production and consumption[59]. Carbon neutrality target before 2060 announced in 2020; Adjusting and Improving Subsidy Policies for New Energy Vehicles in 2020; Interim rules for carbon emissions trading in 2021; and New Energy Automobile Industry Development Plan (2021-2035) in 2021 are among the latest major programs by Chinese government in energy domain[60].

Energy intensity

The progress in energy efficiency improvement varies greatly across region. In China, intensity declined at a far higher rate, indicating that efficiency initiatives are still having an impact. In 2016, global energy intensity would have just improved by 1.1 percent if China had not entered the picture.[61] China's strategy for the development of its energy system is wide-ranging, seeking to create a smart, optimized, clean, and low-carbon energy system while focusing both the demand and supply-side transformations supported by "revolutions" in technology and innovation, as well as market design. China's ambition for the growth of its energy sector represented by the visionary plans (such as 'Ecological Civilisation,' 'Four Revolutions, One Cooperation,' and the 'Belt and Road Initiative'). Reducing energy intensity is a fundamental aspect of demand-side management.

[59] Wang, Y. 2018. The PRC's Renewable Energy Development Leads in the World. Xinhua Net. Available at: http://www.xinhuanet.com/fortune/2018-01/05/c_1122213050.htm.
[60] IRENA (2021). China energy profile. *The International Renewable Energy Agency (IRENA)*. Available at: https://www.irena.org/IRENADocuments/Statistical_Profiles/Asia/China_Asia_RE_SP.pdf. [Accessed on April 2022]
[61] IEA (2017), Energy efficiency 2017, IEA, Paris https://www.iea.org/reports/energy-efficiency-2017

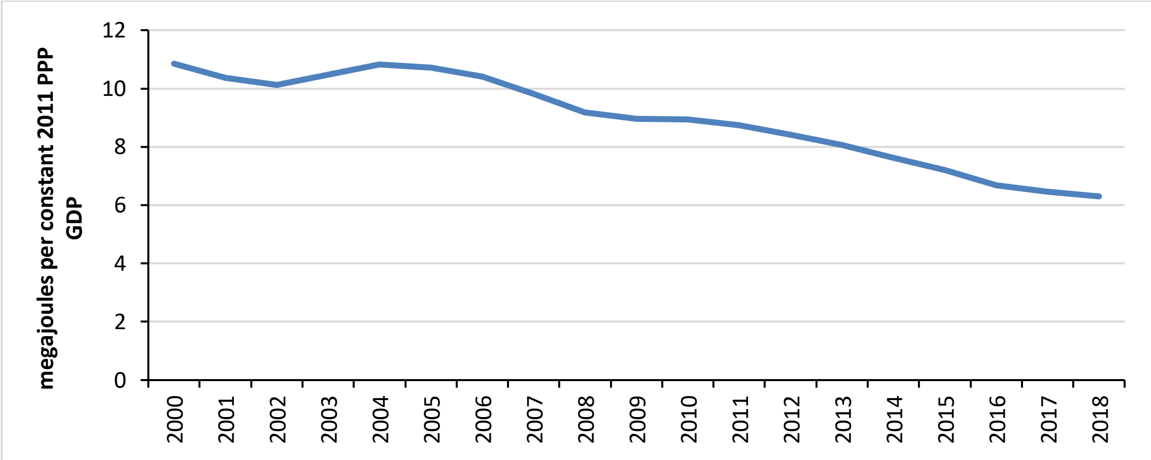


Figure 3-22 Energy intensity of China (2000-2018)

As a result of the strong economic advancement and swift industrialization, the energy consumption has risen substantially. The total primary energy supply is also considerably lower than it would be; otherwise, the advances in energy intensity would not be possible. As shown in **Figure 3-22**, the energy intensity of China has significantly improved (i.e., from 10.9 megajoules per constant 2011 PPP GDP to 6.3 megajoules per constant 2011 PPP GDP) during 2000 to 2018. China's current 13th FYP energy intensity objectives seek to reduce energy intensity by a further 15% by 2020 compared to 2015. Between 2005 and 2020, energy intensity will have been improved by 44% if this goal is met[62].

3.1.1.5 Agricultural productivity

Agriculture not only affects the macroeconomics of a country but is also associated with the food security and employment issues of a country, particularly for developing countries. China's agricultural output grew rapidly from 1979 to 1984 as a result of strong productivity gains.[63,64] Agricultural productivity increase is critical to the rise of national wealth and livelihood of farmers in most developing countries, such as China.[65] The continuation of

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[62] International Energy Chapter. (2018). CHINA ENERGY EFFICIENCY REPORT: Protocol on Energy Efficiency and Environmental Aspects. Available at: https://www.energycharter.org/fileadmin/DocumentsMedia/EERR/EER-China_ENG.pdf
[63] Lin, J. Y. (1992). Rural reforms and agricultural growth in China. American Economic Review, 82, 34 – 51
[64] Wen, G. J. (1993). Total factor productivity change in China's farming sector: 1952 – 1989. Economic Development and Cultural Change, 42, 1 – 41.
[65] Johnson, D. G. (1997). Richard T. Ely lecture: agriculture and the wealth of nations. American Economic Review, 97, 1 – 11.

agricultural productivity growth in China is especially crucial, given agriculture employed nearly 25% of the country's entire labour force in 2021.[66]

For the purpose of meeting the nutritional demands of its ever-increasing population as well as stimulating its economy, the continuation of agricultural productivity growth in China is especially crucial, given agriculture employs nearly 25% of the country's entire labour force in 2021. China’s agricultural sector and economy has been increasing with a double-digit high growth rate in the past decade as shown in **Figure 3-23**.

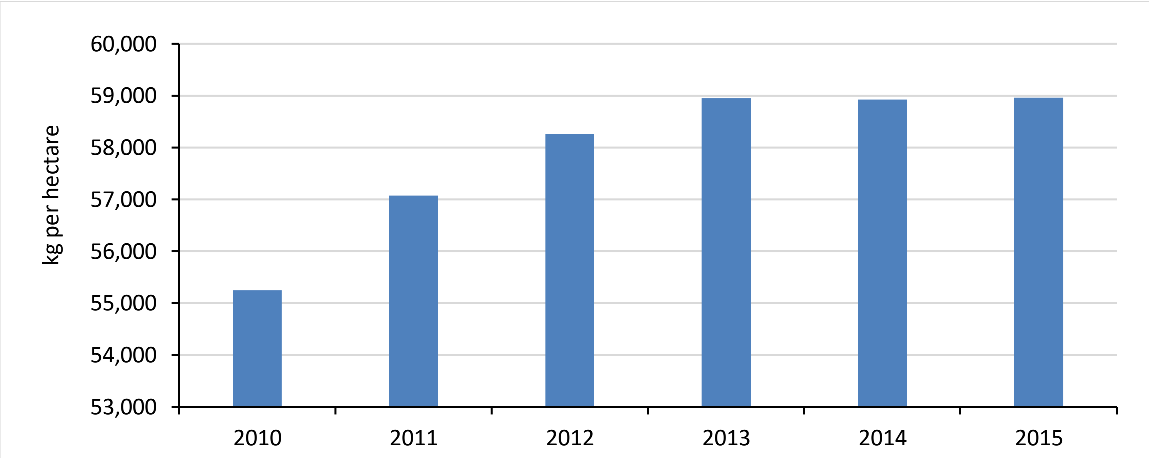

Figure 3-23 Agricultural productivity (cereal yield) in China (2010 - 2015)[67]

3.1.1.6 Greenhouse gas emissions

China's total GHG emissions in 1950 were only 5.46 Mt CO_2eq, implying that total emissions have increased by more than 100-fold in the subsequent 65 years. During the period 1980–2002, China's GHG emissions from fossil fuel burning (energy-related emissions) and cement manufacture (process-related emissions) increased steadily. During this time, emissions climbed from 1,467 to 3,694 million tonnes.[68] This was the highest rate of growth among the world's major economies.[69] China's total emissions tripled in the first decade of the twenty-

[66] China: employment by sector. (n.d.). Statista. Retrieved February 8, 2022, from https://www.statista.com/statistics/270327/distribution-of-the-workforce-across-economic-sectors-in-china/#:~:text=In%202020%2C%20around%2023.6%20percent
[67] FAOSTAT Agriculture database(http://faostat3.fao.org/home/E)
[68] Boden, T. A., Marland, G. & Andres, R. J. Global, Regional, and National Fossil-Fuel CO_2 Emissions http://cdiac.ornl.gov/CO2_Emission/timeseries/national (2016).
[69]Liu, Z. (2015). *China’s Carbon Emissions Report 2015 Energy Technology Innovation Policy*. https://www.belfercenter.org/sites/default/files/legacy/files/carbon-emissions-report-2015-final.pdf

first century, propelling it to first place as the world's top GHG producer in 2007.[70] China was responsible for 25% of world GHG emissions in 2012, with total emissions of 130 Gt CO_2eq.[71] Total GHG emissions of China is shown in **Figure 3-24**.

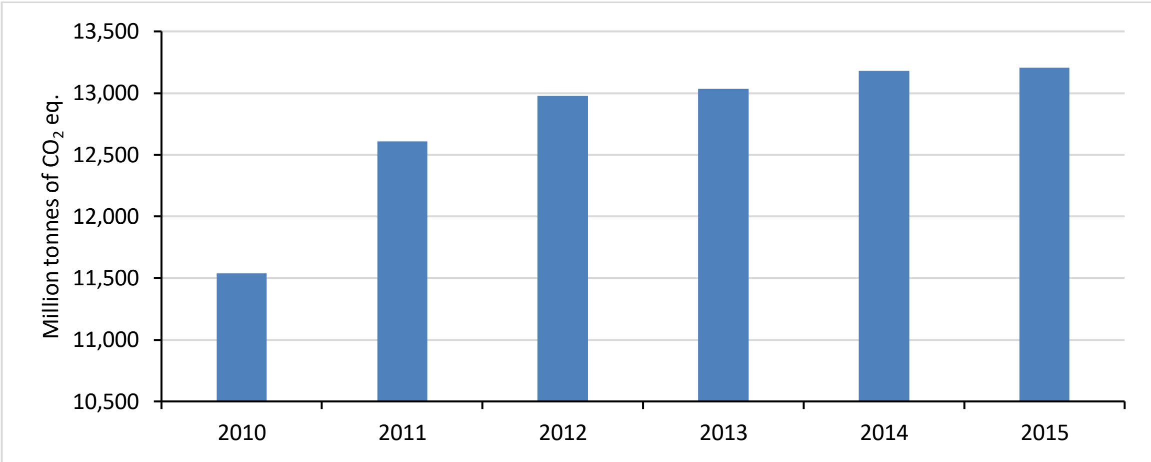

Figure 3-24 China's total GHG emissions (2010 – 2015)

Greenhouse gas from major sectors

Greenhouse gas from energy use

GHG emissions in China are primarily due to the usage of fossil fuels (90%) and cement manufacture (10%). As illustrated in **Figure 3-25**, fossil fuel combustion accounted for 90% of China's energy consumption in 2012, resulting in GHG emissions of more than 8.50 Gt CO_2eq. Between 2010 and 2012, China's carbon emissions accounted for 73 percent of world emissions growth. According to the November 2014 "U.S.-China Joint Announcement on Climate Change and Clean Energy Cooperation," China has committed to peaking its overall GHG emissions by 2030.[72]

[70] Guan, D., Peters, G. P., Weber, C. L. & Hubacek, K. Journey to world top emitter: An analysis of the driving forces of China's recent CO2 emissions surge. Geophysical Research Letters 36, L04709 (2009).
[71] Liu, Z. (2015). *China's Carbon Emissions Report 2015 Energy Technology Innovation Policy*. https://www.belfercenter.org/sites/default/files/legacy/files/carbon-emissions-report-2015-final.pdf
[72] The White House: U.S.-China Joint Announcement on Climate Change. (2014).

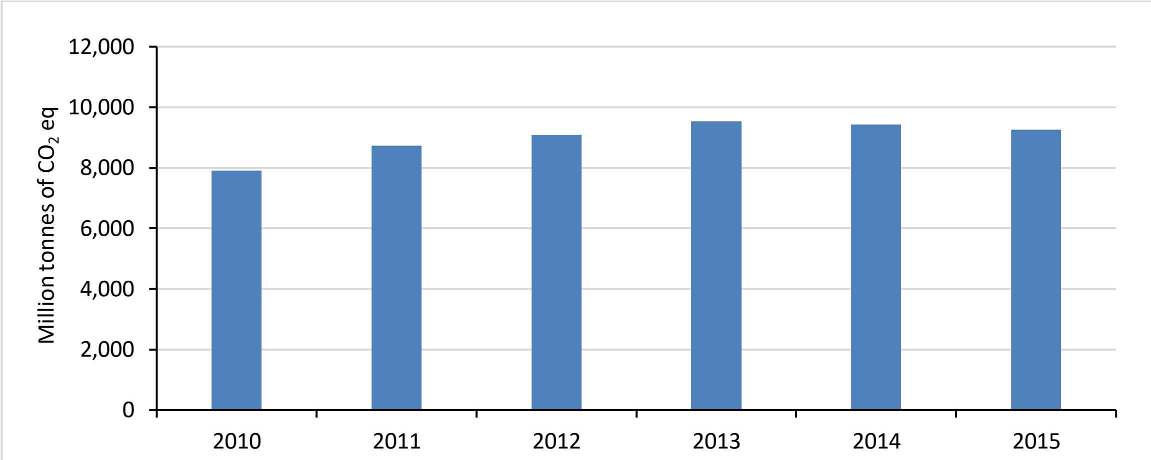

Figure 3-25 GHG from energy use by China (2010 - 2015).

Greenhouse gas from agriculture

The agricultural sector's greenhouse gas emissions are frequently referred to as "survival emissions." Through cattle enteric fermentation, manure management, rice cultivation, cropland, crop residue burning, energy consumption, and land cultivation, agricultural operations primarily release CO_2, CH_4, and N_2O as principal emissions. China is a big agricultural crop producer. Agricultural output has been the foundation of Chinese economic prosperity for decades, and it has long been a policy priority for the Chinese government. The development of agricultural irrigation has been recognised an effective technique to ensure food production due to agriculture's vital role. Agricultural activities have become increasingly reliant on fertilisers and mechanical inputs to assure crop output. Since 1978, the usage of fertilisers, herbicides, and mechanisation has expanded dramatically.[73] As a result, China's investments in agricultural projects such as irrigation have constantly expanded. In 2012, crop farming and animal husbandry accounted for only 7.8% of total GHG emissions in China, but in 2014, China's GHG emissions from agriculture were around 830 Mt CO_2eq, as shown in **Figure 3-26**, with emissions from livestock enteric fermentation accounting for 24.9 percent, emissions from livestock manure management accounting for 16.7%, and emissions from rice cultivation accounting for 187 Mt CO_2eq.[74]

[73] National data. *National Bureau of Statistics of China* http://data.stats.gov.cn/easyquery.htm?cn=C01 (2019).
[74] *The People's Republic of China Second Biennial Update Report on Climate Change Unofficial Translation for Reference Use Only*. (2018). https://unfccc.int/sites/default/files/resource/China%202BUR_English.pdf

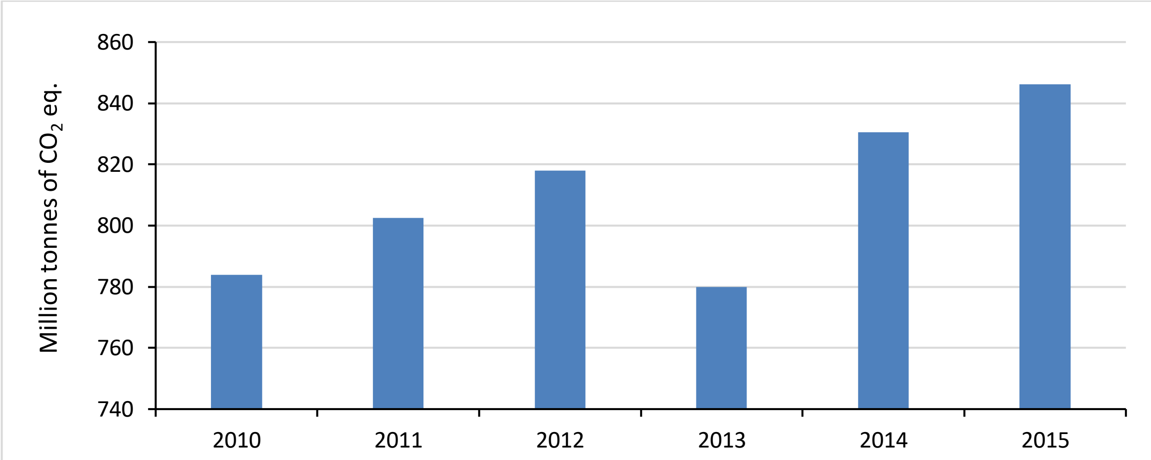

Figure 3-26 GHG emissions from agriculture (2010 - 2015)

Although a number of steps and activities have been taken, China continues to face technological and public awareness challenges, which are required for further reductions in GHG emissions. The Chinese government has taken a two-pronged strategy to decreasing agricultural emissions: reducing emissions from fertilizer use and agricultural waste, and strengthening the soil's ability to absorb carbon.

Greenhouse gas intensity

On a country level, GHG intensity is widely utilized as an indication of efficiency and technological development.[75] As illustrated in **Figure 3-27**, China's GHG intensity has been progressively increasing since 2010. China's emission intensity (at constant pricing) in 2015 was roughly 81 percent of Asia's. The high carbon emissions intensity of China's economy explains this. Given that part of the difference in intensity stems from changes in the structure of China's industrial activity, the high level of GHG intensity shows a large opportunity for lowering GHG emissions in China by controlling emissions intensity up to a point. The Chinese national government's most important mitigation project is now reducing carbon intensity. China's key strategy for increasing national energy efficiency has been the Year Plan. China has set a national aim of achieving a 45 percent reduction in carbon intensity by 2020 (compared to 2005 levels), which has been divided into provinces and achieved through "top-

[75] Raupach, M. R. et al. Global and regional drivers of accelerating CO2 emissions. Proceedings of the National Academy of Sciences 104, 10288-10293 (2007).

down" administrative methods. China's main strategy for achieving its energy-saving and emissions-reduction goals is to use "top-down" command and control measures.

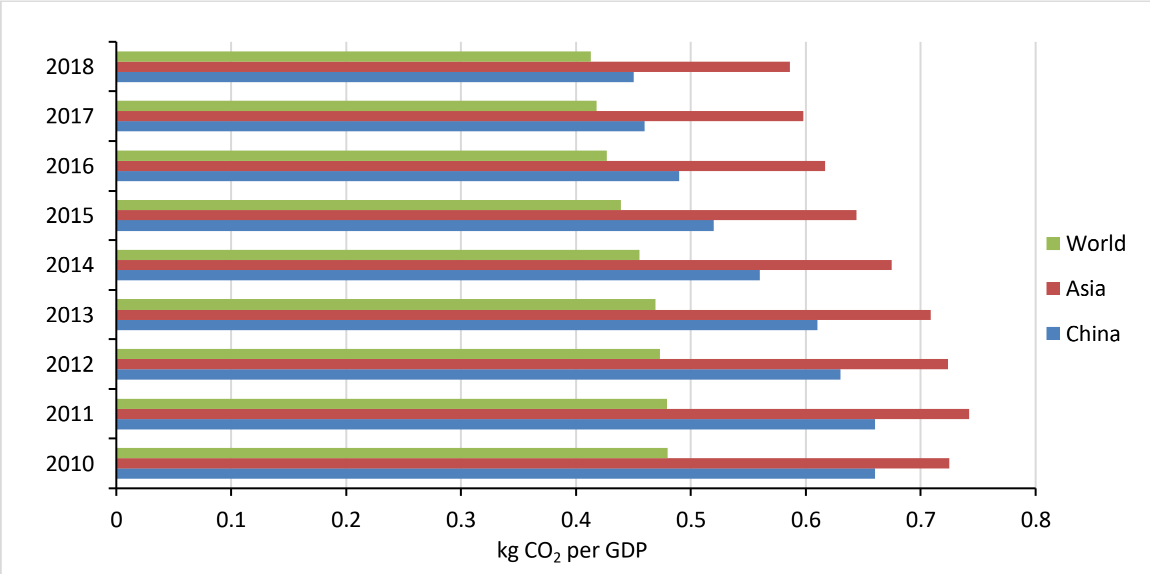

Figure 3-27 GHG intensity from China (2010 - 2015)

3.1.1.7 Human development index (HDI)

The major goal of human development is to lead society towards greater mutual well-being via productive economic activities. Every additional natural resource use and their corresponding environmental emission support positive human resource development. Therefore, in this section of the report we examined the relationship between the Human Development Index (HDI) – a measure of human development - and the growth in natural resource use and emissions. HDI consists of three different domains, viz., literacy rate, life expectancy, and standard of living, while natural resource use here refers to the material use and emissions refers to the energy use which is the dominant sector regarding emissions. The data for direct material use, material footprint, and HDI was sourced from UNDP. The time series here covers the period from 2010 to 2017. All the Asia countries have shown a remarkable improvement in all three domains of HDI since the 1980s. However, six Asian countries (China, India, Indonesia, Pakistan, Thailand, Viet Nam) are selected to investigate the relationship between material use and the HDI as the before mentioned countries are found to be the most significant regarding natural resource use.

3.1.1.8 Material use and HDI

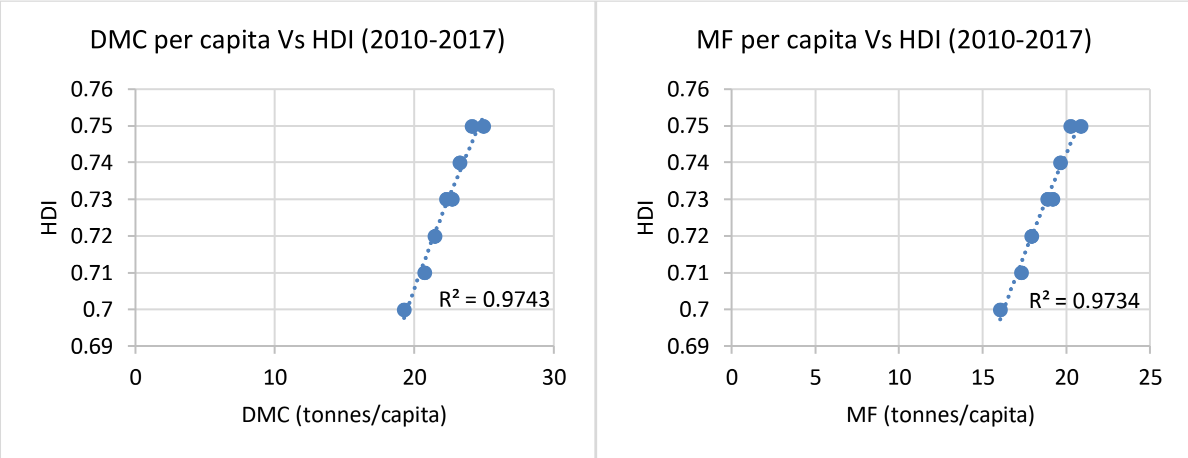

Figure 3-28 The relationship between material use (DMC per capita), and material footprint (MF per capita) versus the human development index (HDI) for China (2010-2017).

Figure 3-28 shows the relationship between DMC and HDI, and the relationship between the material footprint of consumption and HDI in China from 2010 to 2017. For China, the correlation between material footprint and HDI is slightly stronger as compared to direct material use as the value of correlation coefficient "*r*" between DMC and HDI, and material footprint and HDI was 0.9873 and 0.9886, respectively, from 2010 to 2017. The reason is that material footprint of consumption is associated to the use of material and other resources for significant manufacturing activities, and China's economy is highly dependent on its manufacturing sector. In fact, China is the world's largest manufacturer in terms of output and has gained a reputation as the "world's factory" soon after its accession to the World Trade Organization (WTO) in 2001.[76]

3.1.1.9 Economic growth

The most often used indicator for gauging economic growth is gross domestic product (GDP). GDP is the total market value of finished goods and services produced in a country in a specific year. In other words, it is a broader estimate of overall domestic production of any region. In this section, GDP is used as a complementary indicator to show how overall production

[76] https://www.scmp.com/economy/china-economy/article/3114176/china-manufacturing-everything-you-need-know

activities provide a different perspective on domestic material consumption and material footprint in concerned six Asian countries.

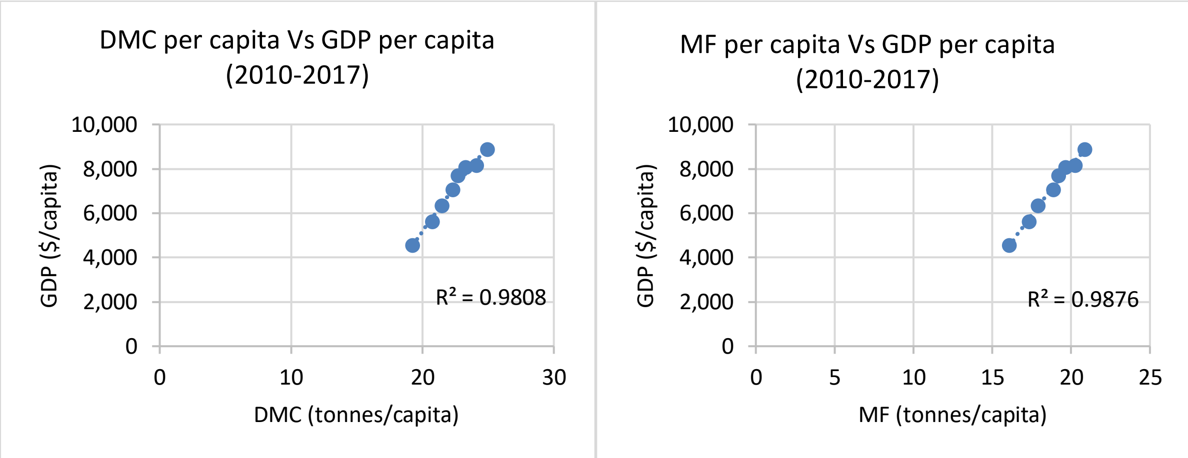

Figure 3-29 The relationship between material use (DMC per capita), and material footprint (MF per capita) versus the GDP per capita, China (2010, 2017)

In **Figure 3-29**, China's DMC per capita (tonnes/capita) and material footprint per capita (tonnes/capita) are plotted against GDP per capita for 2010 and 2017. It can be seen that both DMC per capita and material footprint per capita has a positive and very strong relationship with GDP per capita. However, for China, the correlation between is slightly stronger material footprint and GDP as compared to DMC and GDP as the value of correlation coefficient "r" between material footprint and GDP, and DMC and GDP were 0.9929 and 0.9878, respectively, from 2010 to 2017.

3.1.1.10 Physical trade balance

Globalization is increasing the interdependence of countries for goods; hence embodied/indirect natural resources of traded products is growing in significance. Over the last decades, many countries have changed from being net exporters to importers; but on the other hand, a few countries have changed from being importers to exporters. This can cause a destabilizing effect from fewer exporters supply rising demand in the world economy[77].

[77] UNEP (2020). Sustainable Trade in Resources Global Material Flows, Circularity and Trade. UNEP. https://wedocs.unep.org/bitstream/handle/20.500.11822/34344/STR.pdf.

Physical trade balance is represented in three sectors: agricultural sector, food sector, and construction sector from six selected countries in the Asia Pacific region.

Agricultural sector

The crops (i.e., rice, wheat, tobacco, nuts, etc.), crop residues (i.e., straw, sugar and fodder beet leaves, etc.), and grazed biomass & fodder crops sub-categories are considered under the agricultural sector. China was in a favorable balance of trade in the agriculture, as shown in **Figure 3-30**. The major agricultural imports in China are soybean, cotton, and palm oil.[78] The surplus was climbed rapidly in 2012 since net imports increased by 22% and its growth declined slightly from 2013 to 2017. The largest share of agricultural imports was crops (99%) which increased by 11% over the period 2010 to 2017. China had the world's largest population in 2017. Its PTB per capita increased from 0.06 in 2010 to 0.10 in 2017 (**Figure 3-31**). The PTB per capita emphasized the growth of reliance of China on imports to meet its requirements.

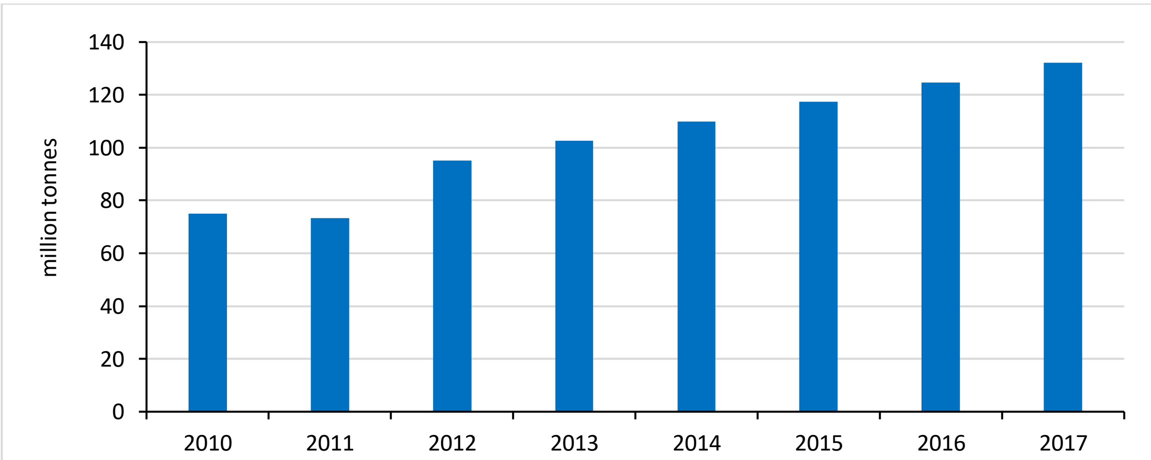

Figure 3-30 Physical trade balance by agricultural sector in China, 2010 to 2017

[78] Gale, F., Hansen, J., & Jewison, M) .2015 .(*China's Growing Demand for Agricultural Imports* .USDA https//:www.ers.usda.gov/webdocs/publications/43939/eib-136.pdf?v=0

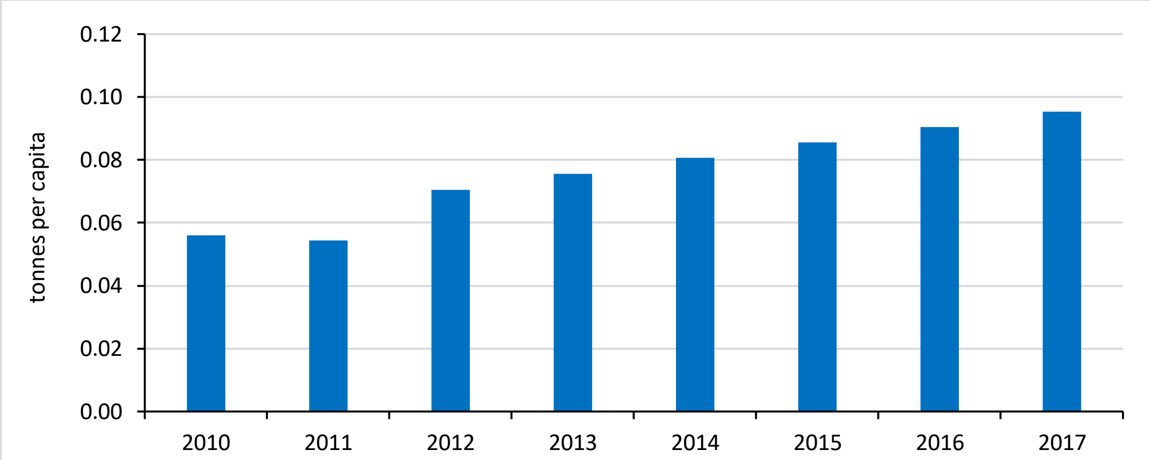

Figure 3-31 Physical trade balance per capita by agricultural sector in China, 2010 to 2017

Food sector

The crop (for food) and wild catch & harvest sub-categories are considered under food sector. China's trade surplus of food sector increased from 75 million tonnes in 2010 to 131 million tonnes in 2017, as presented in **Figure 3-32**. The imported food rose at 6 % on average, over the 2010 to 2017 period where imports sourced from crops (97%) and wild catch and harvest (3%) in 2017. Growth in imported food remained constant at 2% since 2013. By contrast, exported food slightly declined by 1% on average since 2013. China doubled its PTB per capita from 2010 to 0.09 tonnes per capita in 2017 (**Figure 3-33**).

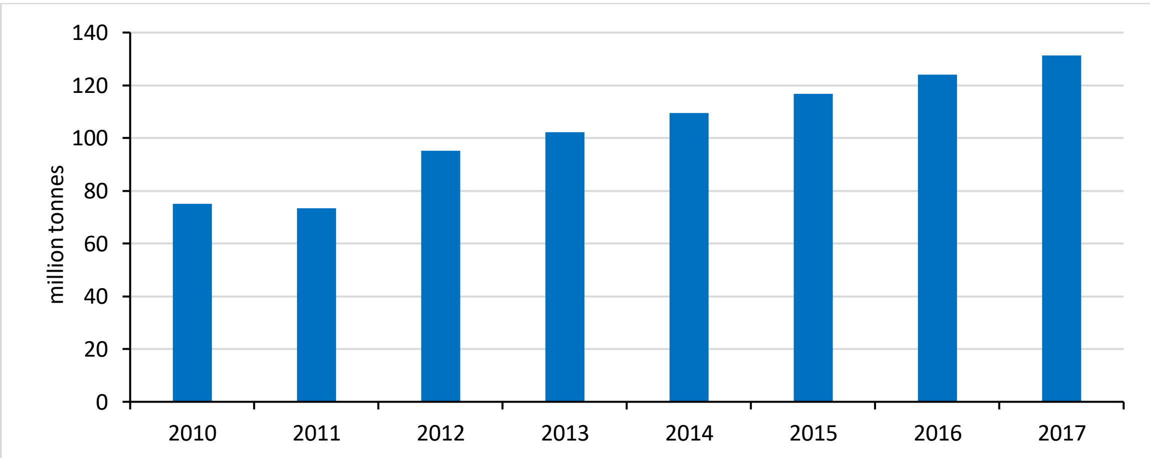

Figure 3-32 Physical trade balance by food sector in China, 2010 to 2017

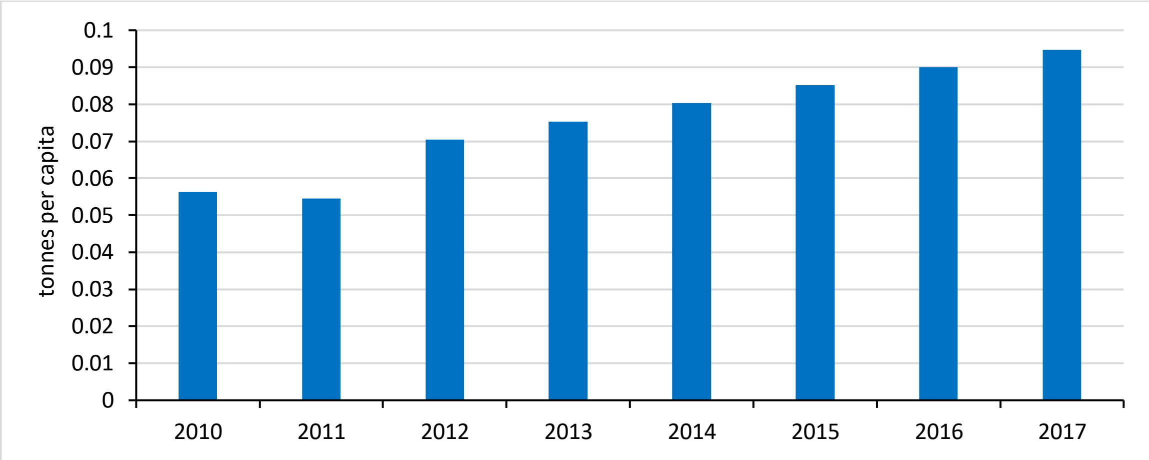

Figure 3-33 Physical trade balance per capita by food sector in China, 2010 to 2017

Construction sector

The non-metallic minerals of construction dominant sub-category are considered under construction sector. As shown in **Figure 3-34**, China's decline of construction sector increased quite rapidly in 2014; this might be caused by the trend of expansion in China's construction activity weakening from the shift of government's policy from large-scale infrastructure developments to household consumption[79] .The decline remained a constant feature in next year. The exported in construction sector was 138 million tonnes in 2017, an average annual growth rate of 8 %over the period 2010 to 2017 .The PTB per capita increased from -0.04 in 2010 to -0.08 in 2017 (**Figure 3-35**).

[79] Construction global)2020 .(*GLOBAL PERSPECTIVES :China's construction sector* .Construction global . https//:constructionglobal.com/facilities-management/global-perspectives-chinas-construction-sector

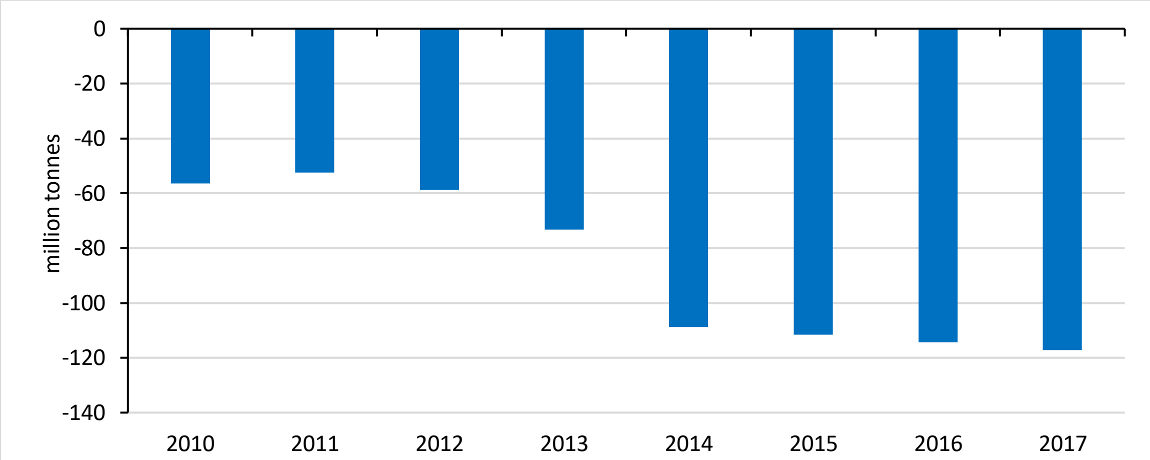

Figure 3-34 Physical trade balance by construction sector in China, 2010 to 2017

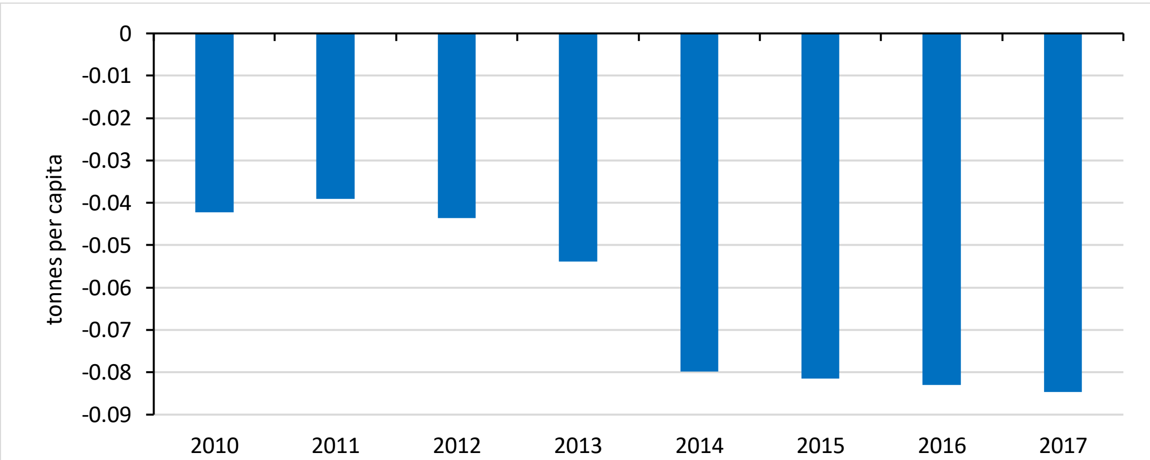

Figure 3-35 Physical trade balance per capita by construction sector in China, 2010 to 2017

3.1.2 Consolidated discussion

In China, renewable energy, material use, land use and GHG emissions are increasingly driven by the increase in population, urbanization, industrial development, and economic growth, which influenced sustainable consumption and production patterns. Especially, the final energy consumption in the industrial sector has increased rapidly in the last two decades, and the share of the energy sector in the GHG emissions is the highest which can have severely impacted climate change, ecotoxicity, eutrophication, etc. Moreover, increased activities in the manufacturing industry, and infrastructure development are causing an increase in water use in construction significantly. Similarly, land use and water use in the agriculture sector are increased which is probably due to the production enough food for the growing population.

It is because there is a nexus especially among land, water, agriculture, and food. Normally, land, water, agriculture, and food have direct relation. However, these are all resources facing scarcity threat. Most of the indicators in terms of per capita were showing a decrease in trends that is proof of scarcity of resources. That is why China is trying to avoid this issue by taking different steps as explained further. The country is trying to shift its development from conventional to green development. China also took part in the High-Level Political Forum, the UN's principal platform for monitoring and reviewing the 2030 Agenda for Sustainable Development and the Sustainable Development Goals, as a voluntary national review. China is also implementing the “Innovative Green Development Program”. China has formulated Policies and Actions responding to Climate Change [80]. China is trying to convert its conventional economy into a green economy by taking multiple steps. Such as the National Ecotourism Development Plan 2016–2025 to divert its tourism into environmentally friendly tourism[81]. The program initiated by China named as “Ecological Civilization”. The aim of this program is to enhance the China’s effort to build a shared future for all life on Earth[82,83]. The People’s Republic of China also passed the Circular Economy Promotion Law at the fourth meeting of the Standing Committee of the 11th National People’s Congress of the People’s Republic of China on August, 2008[84,85,86]. Carbon neutrality target before 2060 announced in 2020; Adjusting and Improving Subsidy Policies for New Energy Vehicles in 2020; Interim rules for carbon emissions trading in 2021; and New Energy Automobile Industry Development Plan (2021-2035) in 2021 are among the latest major programs by Chinese government in energy domain[87]. A summary of SCP indicators and issues considering the DPSIR framework for China is presented in **Table 3-2**.

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[80] http://www.scio.gov.cn/zfbps/32832/Document/1715506/1715506.htm
[81] Li, Y., Zhang, L., Gao, Y., Huang, Z., Cui, L., Liu, S., Fang, Y., Ren, G., Fornacca, D. and Xiao, W. (2019). Ecotourism in China, Misuse or Genuine Development? An Analysis Based on Map Browser Results. Sustainability, 11(18), 4997–. doi:10.3390/su11184997
[82] Wei, F., Cui, S., Liu, N., Chang, J., Ping, X., Ma, T., Xu, J., Swaisgood, R.R. and Locke, H. (2021). Ecological civilization: China’s effort to build a shared future for all life on Earth, Natl. Sci. Rev., Vol. 8, nwaa279
[83] https://www.adb.org/sites/default/files/publication/545291/eawp-021-ecological-civilization-prc.pdf
[84] https://www.greengrowthknowledge.org/sites/default/files/downloads/policy-database/CHINA%29%20Circular%20Economy%20Promotion%20Law%20%282008%29.pdf
[85] Zhu, Junming; Fan, Chengming; Shi, Haijia; Shi, Lei (2018). *Efforts for a Circular Economy in China: A Comprehensive Review of Policies. Journal of Industrial Ecology, 23(1),* ***110-118.*** doi:10.1111/jiec.12754
[86] https://www.efchina.org/Reports-en/report-lceg-20201210-en
[87] IRENA (2021). China energy profile. *The International Renewable Energy Agency (IRENA)*. Available at: https://www.irena.org/IRENADocuments/Statistical_Profiles/Asia/China_Asia_RE_SP.pdf. [Accessed on April 2022]

Table 3-2 A summary of SCP indicators and issues considering the DPSIR framework for China.

Drivers	State/ impact	Responses
- Demographic growth - Urbanization - Economic growth - Industrial development - Increasing domestic demand owing to an increase in GNI - Second highest GDP - The largest population - Increasing population (1.26 billion in 2000 to around 1.41 billion in 2020) - Increased economic activity (US$ 960 per capita in 2000 to US$ 10,216 per capita in 2020 and total GDP from US$ 1.2 trillion in 2000 to $US 14.72 trillion in 2020)	- total DMC in China has increased from around 26 billion tonnes to more than 35 billion tonnes (2010-2017) - electricity consumption of the industrial sector increased by 30 million TJ from 2000 to 2019 - The construction sector is the major contributor to land use. - land use of the construction, food, and transportation sectors was significantly from 1990 to 2018. - The agricultural sector is the major contributor to water use. - GHG emissions increased around 1250 million tonne CO_2eq. 2010 to 2015.	China is trying to replace its conventional irrigation system with an efficient irrigation system. - China has released a national plan to implement SDGs. - China has formulated Policies and Actions responding to climate change. - Green growth in action: China - Member of a voluntary national review of The High-level Political Forum, United Nations central platform for follow-up and review of the 2030 Agenda for Sustainable Development and the Sustainable Development Goals. China has implemented its "National Ecotourism Development Plan 2016–2025" to divert its tourism into environmentally friendly tourism.

3.2 India

- India is the seventh-largest country by size and the second-most populous country.
- The water use footprint of the agriculture and transport sectors increased during 2010 to 2018.
- The land use footprint of the agriculture sector was almost constant during 1990 to 2018.
- During 2010-2017, the DMC showed a continuously increasing trend still per capita DMC is more than two times lower than that of Asia and the World.
- India has committed to increasing the share of renewable energy up to 50% by 2030 to fulfill its energy requirements.
- It has doubled its per capita physical trade balance from 2010 to 2017.

India — officially known as the Republic of India — is located in South Asia, bordered on the east by the Bay of Bengal, the west by the Arabian Sea, and the south by the Indian Ocean; mainland consists of four regions: mountainous zone, the Indo-Gangetic Plain, the deserts, and the southern peninsula known for the Deccan plateau[88]. It is the seventh-largest country by size which is occupying a total area of 1,269,219 square miles or 3.3 million square kilometers[89]. Furthermore, it is the second-most populous country consisting of a total population of 1.38 billion people as shown in **Figure 3-36**, with an annual growth rate of 1.0% in 2020[90].

[88] National portal. (2022). India at a glance. *National portal of India.* Retrieved on, January 23, 2022, from https://www.india.gov.in/india-glance/profile
[89] Wikipedia contributors. (2022). India. *In Wikipedia, The Free Encyclopedia*. Retrieved on January 23, 2022, from: https://en.wikipedia.org/w/index.php?title=India&oldid=1071730997
[90] The World Bank. (2020). World Development Indicators. *The World Bank database.* Retrieved on, January 23, 2022, from: https://data.worldbank.org/indicator

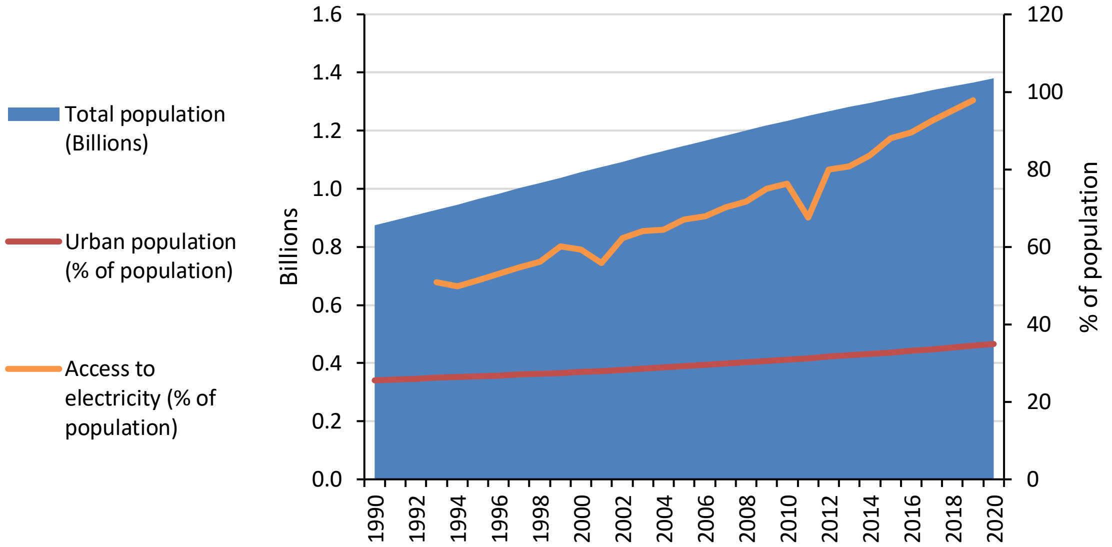

Figure 3-36 Total population, urban population and population having access to electricity[91]

The population of India has grown swiftly over the past few decades; from 0.8 billion in 1990 to 1.38 billion in 2020 as shown in **Figure 3-36**. Nearly 98% of the population has access to electricity and the people residing in urban areas account for almost 35% of the total population of the country as presented in **Figure 3-37**.

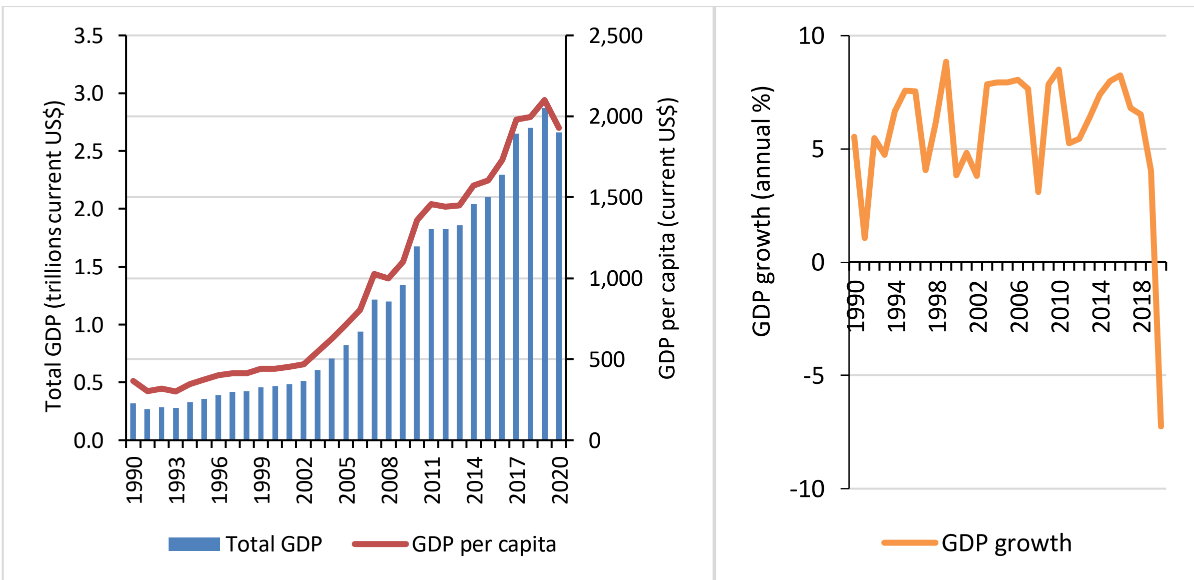

Figure 3-37 Total GDP, GDP per capita, and GDP annual growth[3]

[91] The World Bank. (2020). World Development Indicators. *The World Bank database.* Retrieved on, January 23, 2022, from: https://data.worldbank.org/indicator

Rice, wheat, cotton, sugarcane, coconut, spices, jute, tobacco, tea, coffee, and rubber are the major commodities belonging to the agriculture sector of the country. The manufacturing industry is extremely diverse, encompassing both heavy and high-tech businesses. Major economic growth can be observed after 2000 due to the rapid industrialization as presented in **Figure 3-37**. During the past three decades between 1990 to 2020, the GDP of the country has increased many folds, i.e., from 0.3 trillion to 2.6 trillion, and per capita GDP raised from almost 300 USD to 2100 USD. However, due to the pandemic, the economic growth showed a historic low after 2018. The consumption and production patterns of India have risen over the last few decades and resource depletion and pollution have continually increased, placing significant strain on the ecosystem, well beyond its regenerative and assimilative capacity. As a result, both local (such as resource scarcity) and global (such as biodiversity loss and climate change) issues have developed or have become much worse. Therefore, in this country report, a wide range of SCP indicators considering the DPSIR framework is discussed in detail and the overview is presented in **Figure 3-38** below.

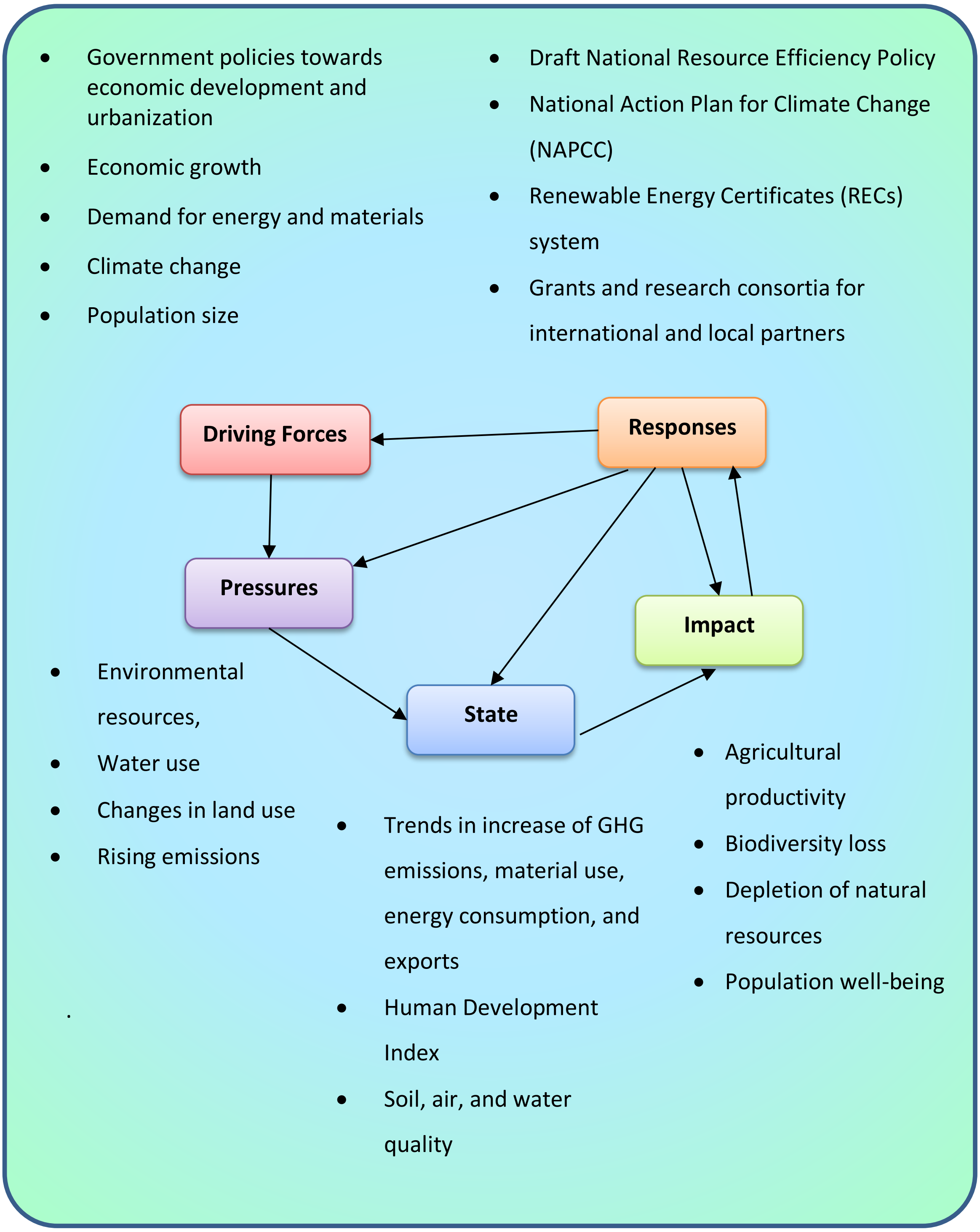

Figure 3-38 DPSIR framework for India

3.2.1 Indicators

3.2.1.1 Water use

In agriculture sector, it deals with the water use by food crops (wheat, maize, cereals etc.), oil, fiber, non-perennial, spices, aromatic, drug and pharmaceutical crops, beverage crops perennial crops, plant propagation, and water use in livestock farming based on consumption footprint[92].The water use footprint of the agriculture sector of India increased from 2010 to 2018. In 2018, the total water use footprint was around 203 billion cubic meters per year. Overall, it increased with the rate of 1.83 billion cubic meters per year from 2010 to 2018. A slight decrease was observed only during 2011 and 2012, then onwards it showed a gradual increase in trends. A slight decrease in 2011-12 is possibly due to the relative slowdown in economy and slightly lowering in land use footprint of the agriculture sector of India. The overall increase in water use footprint of the agriculture sector is possibly due to the expansion of the land use in the agriculture sector. The time series of water use footprint of the agriculture sector of India from 2010 to 2018 is shown in **Figure 3-39**.

Water use footprint of the food sector

It deals with the water use by processing, preserving, and manufacture of meat and fish-based products, cereal-based products, food crop products, mixed food and feed, cocoa, fiber-based products, chocolate and sugar confectionery, vegetable and animal oils and fats, and manufacture of dairy products, alcoholic and other beverages, tobacco products based on consumption footprint[93].

Water use footprint of the food sector of India showed an increasing trend. In 2010, the water use of the food sector in India was 7.22 billion cubic meters, increasing at the rate of 0.1 billion cubic meters per year from 2010 to 2018. The highest water use footprint of the food sector was noticed in 2018 at 8.04 billion cubic meters. Water use footprint of the food sector should not mix with the agriculture sector because the food sector deals with the food industry not the food crops. There is very weak correlation between agriculture and food sectors because

[92] SCP-HAT (http://scp-hat.lifecycleinitiative.org/module-2-scp-hotspots/)
[93] SCP-HAT (http://scp-hat.lifecycleinitiative.org/module-2-scp-hotspots/)

of different parameters involved according to definitions. However, land use footprint and water use footprint from 2010 to 2018 follow same trends. That shows that water use is strongly correlated to water use land use footprint. The decrease in water use in the food sector is possibly due to the sudden decrease in import of non-alcoholic beverages in 2013. The time series of water use footprint of the food sector of India from 2010 to 2018 is shown in **Figure 3-39**.

Water use footprint of the tourism sector

It is defined as the water use in hotels and restaurants for accommodation and food service activities based on consumption footprint. The water use footprint of the tourism sector of India showed a slight decreasing trend in 2018 as compared to 2010. In 2010, the total water use footprint was 3.88 billion cubic meters per year. In 2011 and 2012, it decreased sharply then revived in the next year. The decrease in water in the tourism sector from 2010 to 2011 is more likely due to the slowdown the economic activities of India. The tourism revenue growth was also decreased in 2011[94]. From 2013 onwards, it was almost constant. The decrease in water use footprint of the tourism sector is probably due to the slowdown in the economic activities of India in the same years. The time series of water use footprint of the tourism sector of India from 2010 to 2018 is shown in **Figure 3-39**.

Water use footprint of transport sector

It is defined as the water use in land transport, water transport, air transport, transport via pipeline, warehousing and support activities for transportation based on consumption footprint. The water use footprint of the transport sector of India slightly increased by 7 percent in 2018 as compared to 2010. In 2010, the total water use footprint of India was 0.41 billion cubic meters per year. The decrease in 2011 and 2012 is most probably due to the increase in land transportation activities almost in the same manner. The change in land transportation activities exhibited the similar trends as shown in **Figure 3-39**. A slight increase in water use footprint of the transport sector of India is most probably due to the growing economic activities and population expansion. However, the proportion of water use

[94] https://www.ceicdata.com/en/indicator/india/tourism-revenue-growth

footprint in the transport sector is very little as compared to the other sectors. The time series of water use footprint in the transport sector of India from 2010 to 2018 is shown in **Figure 3-39**.

Water use footprint of construction sector

It is defined as the water use in construction of all buildings, roads and railways, utilities and other civil engineering activities based on consumption footprint[95]. The water use footprint in the construction sector of India decreased by 1.95 billion cubic meters in 2018 as compared to 2010. In 2010, the total water use footprint of India was 7.15 billion cubic meters per year. The water use footprint of the construction sector increased in 2011-12 perhaps due to the expansion of highways network during this period[96] and increase in construction activities could also be another justification of this change. The time series of water use footprint of the construction sector of India from 2010 to 2018 is shown in **Figure 3-39**.

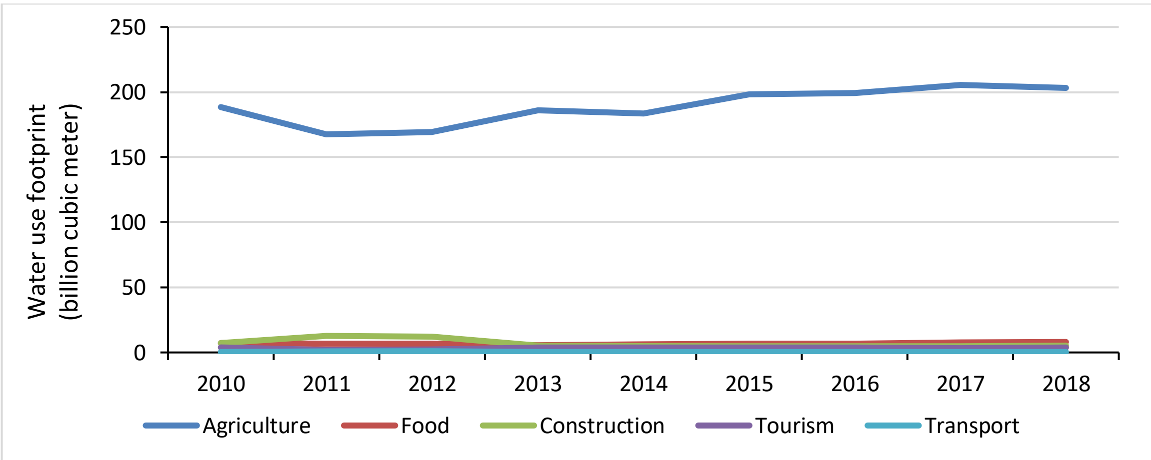

Figure 3-39 Water use footprint of different sectors of India

3.2.1.2 Land use

Land use footprint of agriculture sector deals with the land used for the cultivation of food crops (wheat, maize, cereals etc.), oil, fiber, non-perennial, spices, aromatic, drug and pharmaceutical, crops beverage crops perennial crops, plant propagation, and land use in

[95] SCP-HAT (http://scp-hat.lifecycleinitiative.org/module-2-scp-hotspots/)
[96] https://timesofindia.indiatimes.com/india/at-30km-a-day-govt-hit-top-gear-in-nh-building-in-fy19/articleshow/68769862.cms

livestock farming based on consumption footprint[97]. Land use footprint of the agriculture sector in India was almost constant from 1990 to 2018. The agricultural contribution to the economy was highest during this period[98]. In 1990 the land use footprint of the agriculture sector in India was 78.51 million hectares which increased by 2.7 million hectares by the end of 2018. The highest land use footprint of the agriculture sector was noticed in 2017 i.e., 85.56 million hectares. Overall, it increased at the rate of 0.051 million hectares per year from 1990 to 2018. The increase in land use footprint of the agriculture sector is possibly due to the growing contribution of the agriculture sector in India's economy[99]. The time series of land use footprint of the agriculture sector of India from 1990 to 2018 is shown in **Figure 3-40**.

Land use footprint of transport sector

It is defined as the land use in land transport, water transport, air transport, transport via pipeline, warehousing and support activities for transportation based on consumption footprint[100]. Land use footprint of the transport sector in India decreased significantly, especially in the last decade. In 1990, the land use footprint of the transport sector in India was 0.690 million hectares. The highest land use footprint of the transport sector was noticed in 2001 that was 1.880 million hectares. Overall, it decreased with the rate of 0.007 million hectares per year from 1990 to 2018. The time series of land use footprint of the transport sector of India from 1990 to 2018 is shown in **Figure 3-40**.

Land use footprint of the tourism sector

It is defined as the land use in hotels and restaurants for accommodation and food service activities based on consumption footprint. Land use footprint of the tourism sector in India was 2.20 and 3.32 million hectares in 1990 and 2000, respectively. Land use footprint of the tourism sector increased significantly from 2000 to 2001, then it declined sharply from 2005 to onwards. The sudden decrease after 2005 is mainly due to the closure of nearly five thousand one-star hotels in India. Overall, it decreased with the rate of 0.0329 million hectares per year from 1990 to 2018. The land use footprint of the tourism sector abruptly

[97] SCP-HAT (http://scp-hat.lifecycleinitiative.org/module-2-scp-hotspots/)
[98] https://www.fao.org/aquastat/statistics/query/results.html
[99] https://www.fao.org/aquastat/statistics/query/index.html
[100] SCP-HAT (http://scp-hat.lifecycleinitiative.org/module-2-scp-hotspots/)

increased from 2000 to 2001 possibly due to the fast-growing number of hotels in India during the same time[101]. The time series of land use footprint of the tourism sector of India from 1990 to 2018 is shown in **Figure 3-40**.

Land use footprint of the construction sector

It is defined as the land use in construction of all buildings, roads and railways, utilities and other civil engineering activities based on consumption footprint. Land use footprint of the construction sector of India was showing a rapid increase, especially in the late 2010s. In 1990 the land use of the construction sector in India was 0.68 million hectares which was increased by 4.18 million hectares by the end of 2018. The highest land use footprint of the construction sector was noticed in 2007 i.e., 5.89 million hectares. Overall, it was increased at a rate of 0.19 million hectares per year from 1990 to 2018. Moreover, it was noticed that land use footprint in construction sector has increased rapidly after 2004. Perhaps, due to the rapid construction in the private corporate sector could be a main reason of this increase in 2004 and onwards[102]. Then, land use footprint in the construction declined in 2009 due to the global economic depression. Overall, the increase in land use footprint of the construction sector probably due to the rapid increase in economic development and population expansion. The time series of land use footprint of the construction sector of India from 1990 to 2018 is shown in **Figure 3-40**.

Land use footprint of food sector

It deals with the land use for processing, preserving, and manufacture of meat and fish-based products, cereal-based products, food crop product, mixed food and feed, cocoa, fiber-based products, chocolate and sugar confectionery, vegetable and animal oils and fats, and manufacture of dairy products, alcoholic and other beverages, tobacco products based on consumption footprint[103]. Land use footprint of the food sector of India showed an increasing trend from 1990 to 2018. In 1990, the land use footprint of the food sector in India was 13.72

[101] https://www.ceicdata.com/en/india/memo-items-number-of-hotels-and-hotel-rooms/number-of-hotels-rooms-one-star
[102] https://www.ceicdata.com/en/india/nas-20042005-capital-formation-gross-capital-formation-by-institution-current-price/gdp-gfcf-private-corporate
[103] SCP-HAT (http://scp-hat.lifecycleinitiative.org/module-2-scp-hotspots/)

million hectares which increased by 18.365 million hectares by the end of 2018. In terms of percentage, total land use of India increased by almost 0.7 percent. The highest land use footprint of the food sector was noticed in 2011 i.e., 34.67 million hectares. Overall, it increased with the rate of 0.773 million hectares per year from 1990 to 2018. The increase in land use footprint of the food sector due to the increase in economic development and population expansion. The time series of land use footprint of the food sector of India from 1990 to 2018 is shown in **Figure 3-40**.

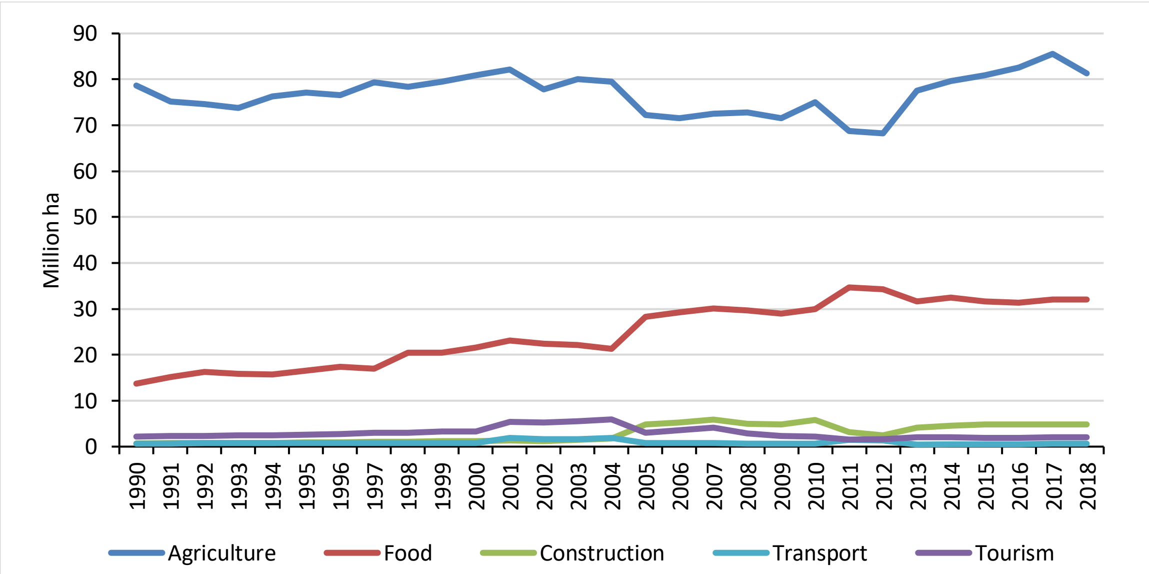

Figure 3-40 Land use footprint of different sectors of India

3.2.1.3 Material use

Figure 3-41 shows the DMC of India from 2010 to 2017. As presented in **Figure 3-41**, the total DMC in India has increased from around 5.8 billion tonnes to around 7.4 billion tonnes in just seven years. During the concerned duration (2010-2017) the DMC in the country showed a continuously increasing trend. The overall increase in the country's DMC was 28%. Increase in population is the reason behind this increase in DMC of the country. The countries population increased to around 1.34 billion in 2017 from 1.23 billion in 2010. The overall increase in the country's population was 8.5%. Another reason can be the enhanced economic activities that caused a tremendous increase in countries gross domestic product (GDP). From 2010 to 2017, the overall increase in the country's GDP was 58%.

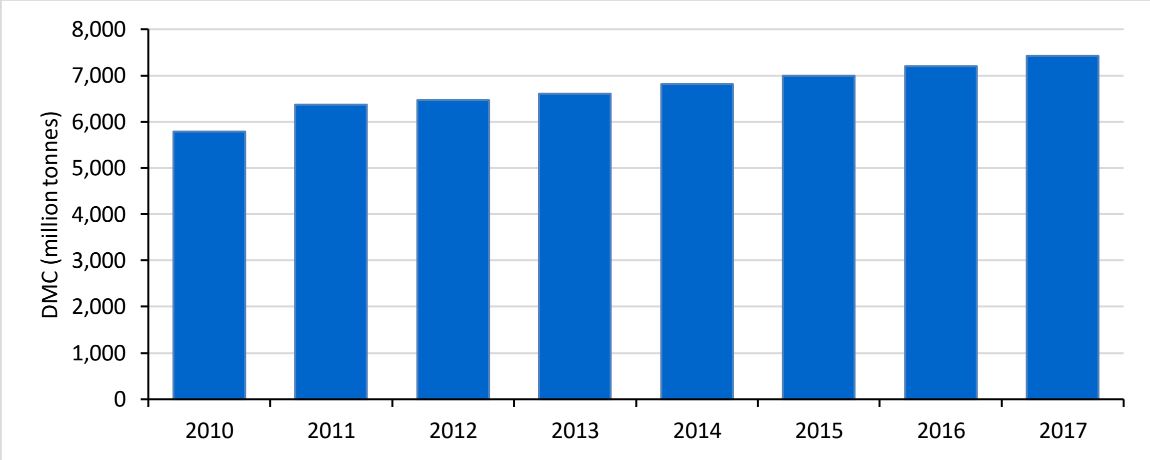

Figure 3-41 Domestic material consumption in India (2010 – 2017)

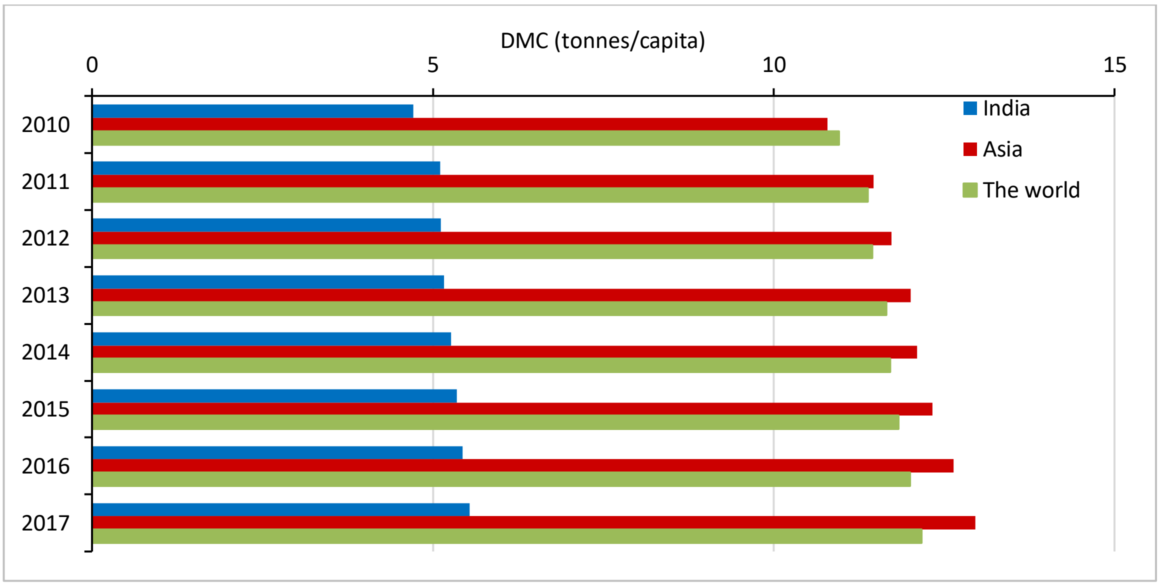

Figure 3-42 Per capita domestic material consumption in India, Asia, and the world (2010-2017)

Figure 3-42 shows the per capita DMC of India, Asia, and the world from 2010 to 2017. The country's per capita DMC increased with a rate of 18% and reached 5.54 tonnes per capita in 2017 from 4.71 tonnes per capita in 2010. It can be seen from **Figure 3-41** and **Figure 3-42** that the country's per capita DMC remained low despite a huge rise in the overall DMC throughout the concerned time period. Moreover, the country's per capita DMC is more than two times lower as compared to the per capita DMC of overall Asia as well as the World. The reason for low per capita DMC despite high rise in overall DMC is the large population the country needs to serve.

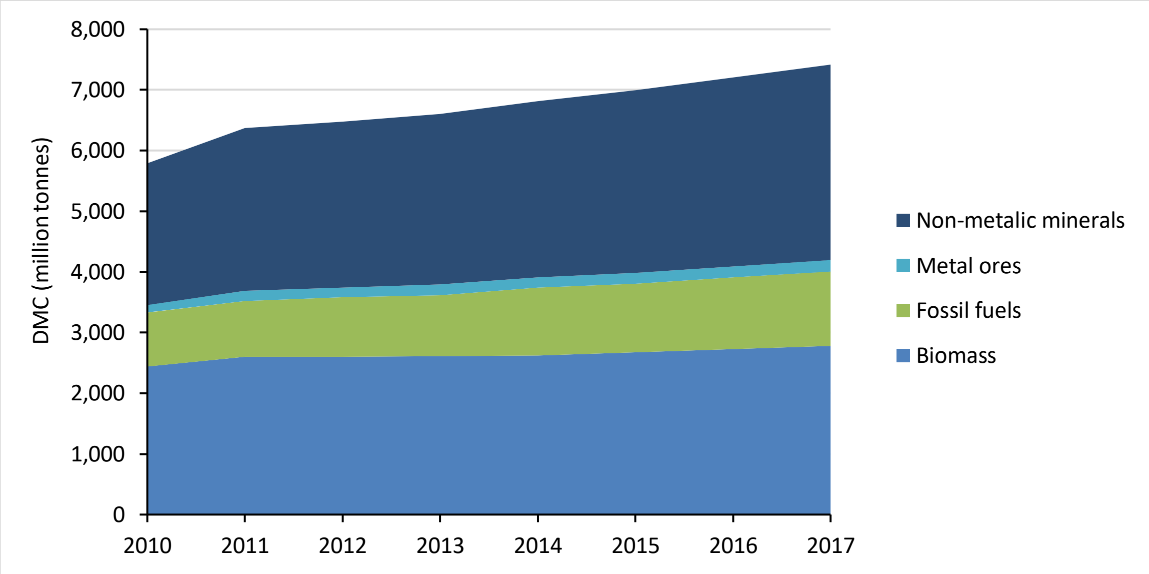

Figure 3-43 Domestic material consumption by material category in India (2010 – 2017)

Figure 3-43 presents the category-wise DMC in India. It can be seen that all material categories showed an increasing trend in the final consumption. From 2010 to 2017, the average annual growth in DMC of biomass, fossil fuels, metal ores, and non-metal minerals has increased at a rate of 0.016%, 0.040%, 0.057%, and 0.040%, respectively. The percentage growth in metal ores consumption is the highest among all four material categories, followed by non-metallic minerals. However, in absolute terms, the non-metallic minerals has the highest share in the country's overall material consumption with more than 3.2 billion tonnes in 2017, followed by biomass, fossil fuels, and metal ores with a total of 2.8, 1.2, and 0.2 billion tonnes, respectively. The overall total annual DMC of biomass, fossil fuels, metal ores, and non-metallic minerals has increased with a rate of 14%, 37%, 57% and, 38% in 2017 from 2010. These statistics indicate that India's economy is moving away from biomass-based materials and energy systems and adopting the mineral-based systems, similar to industrial economies.

Material use by major sectors

Natural resources are the backbone for any economic development in any nation. India, one of the world's fastest-growing economies, has grown its material consumption from 5.8 billion tonnes in 2010 to 7.4 billion tonnes in 2017. It has a GDP of USD 2.6 trillion (as of 2017). Improved resource efficiency and the utilization of secondary raw materials might be a way to reduce the trade-off in India between economic growth, resource restrictions, and environmental well-being. According to the latest update from the Ministry of Environment, Forest and Climate Change-released Draft National Resource Efficiency Policy, India's material consumption is predicted to rise further to meet the needs of an expanding population, fast urbanization, and rising ambitions.[104] **Figure 3-44** shows the material used in six major sectors in India.

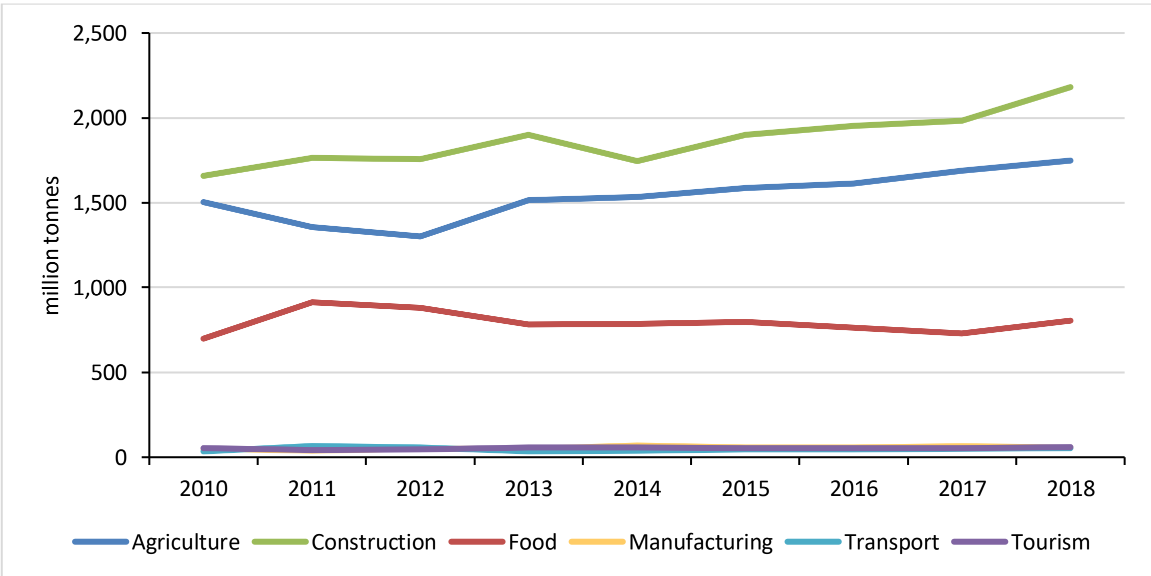

Figure 3-44 The sector-wise material footprint in India (2010-2018)

It can be seen from **Figure 3-44** that the construction sector has the highest material consumption with a steady increase during the considered time series. The overall material consumption by the construction sector increased by more than 32%, reaching 2.2 billion tonnes in 2018 from 1.7 billion tonnes in 2010. On the other hand, the agriculture sector is

[104] https://www.business-standard.com/article/news-cm/natural-resources-consumption-to-grow-further-on-increasing-population-rapid-urbanization-and-growing-aspirations-119082000729_1.html

the second largest sector in the country regarding material consumption. The material consumption of the agriculture sector was around 1.5 billion tonnes in 2010 and increased with a rate of 16% reaching more than 1.7 billion tonnes in 2018. The third-largest sector regarding material consumption is the food sector in the country. The sectors including tourism, manufacturing, and transport had the lowest contribution among the concerned sectors. However, the overall growth in material consumption of the transport sector was 54% and reached to 53.61 million tonnes in 2018 from 34.73 million tonnes in 2010, which was the highest among all six concerned sectors.

Material Intensity

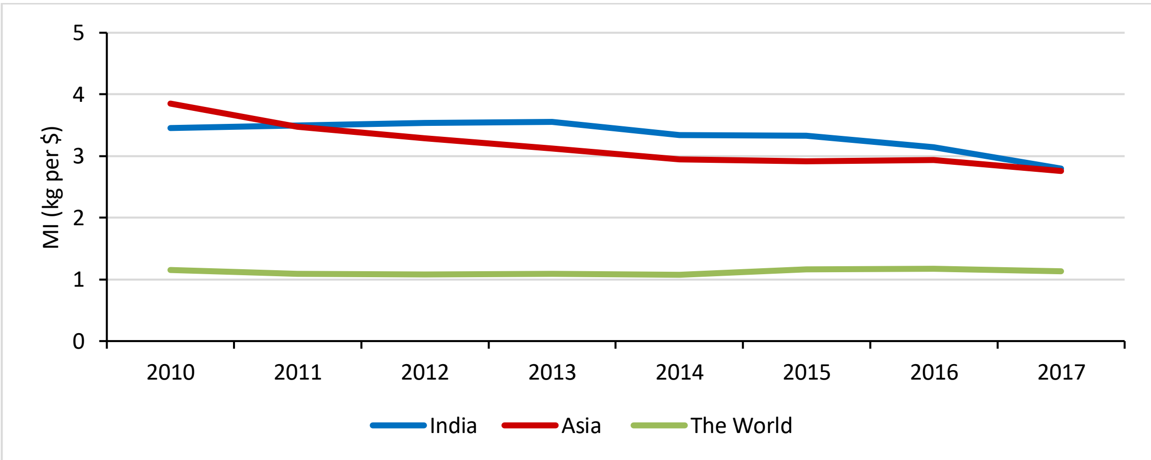

Figure 3-45 Material intensity for India, Asia, and the World (2010 – 2017)

Figure 3-45 exhibits the comparison of material intensity (kg per $) — the amount of material to produce one US$ in terms of GDP — between India, Asia, and the world. The material intensity of the world remained almost constant during 2010-2017. On the other hand, there was a noticeable improvement in the material intensity of India and overall, around the Asian region as well. The material intensity of both India and the overall Asian region decreased by around 20% and 29%, respectively, from 2010 to 2017. In spite of this huge improvement, the material intensity of India and the overall Asian region is still 2.5 times and 2.4 times higher than the overall world's material intensity, respectively.

Material footprint of consumption

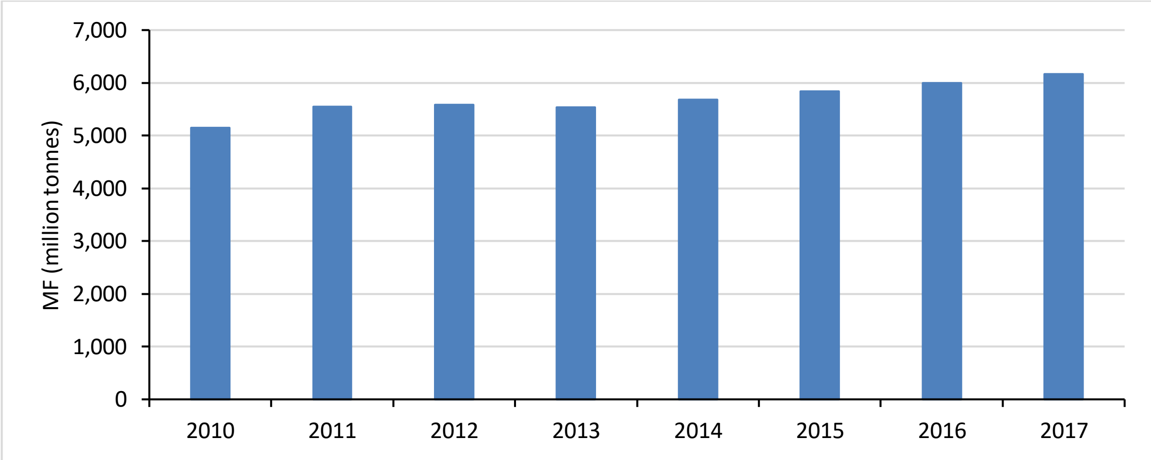

Figure 3-46 The material footprint of consumption in India (2010 – 2017)

Figure 3-46 shows the material footprint of consumption in India. It can be seen that the material footprint of consumption has increased in India from 2010 to 2012, a decline was noticed in 2013. This may be because of a decrease in the industrial growth caused by a deceleration in mining and quarrying, and unsatisfactory performance by the manufacturing sector.[105] After 2013, the material footprint of the country grew with an increasing trend. The material footprint of the country was more than 5.5 billion tonnes in 2013 that increased to more than 6 billion tonnes in 2017. From 2010 to 2017, the overall increase in the country's material footprint was about 20%.

[105] https://assets.kpmg/content/dam/kpmg/pdf/2014/07/India-Economic-Survey-2013-14%E2%80%93Key-Highlights.pdf

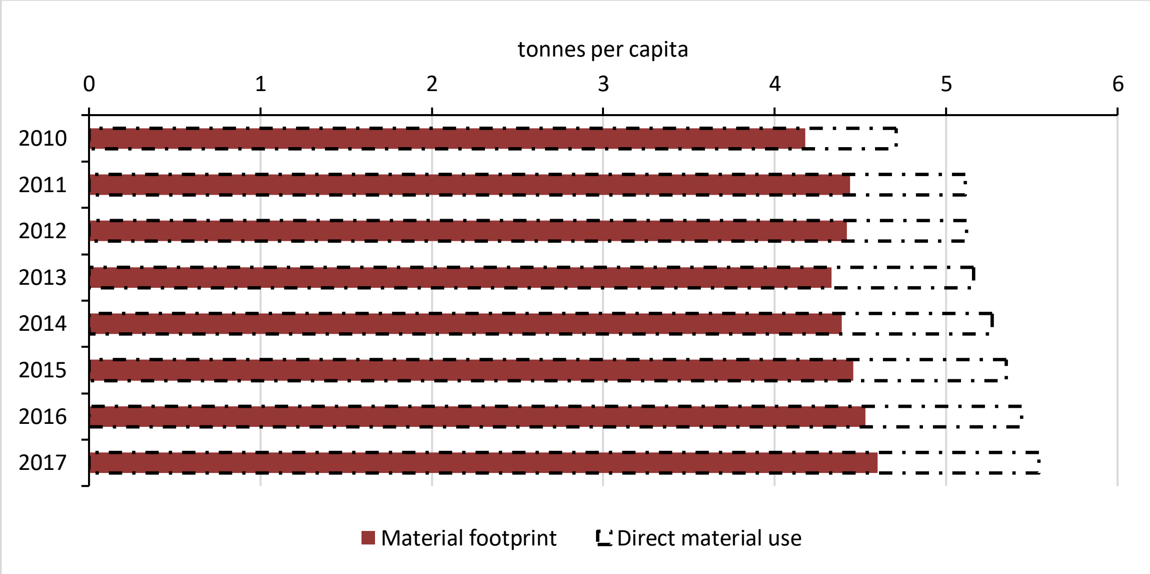

Figure 3-47 Material footprint per capita compared to domestic material consumption per capita in India (2010-2017)

Figure 3-47 compares the material footprint per capita with the DMC per capita of India from 2010 to 2017. The DMC is associated with large extraction and significant manufacturing activities while the material footprint represents the material consumption for the production systems. It can be seen from **Figure 3-47** that India has a higher DMC per capita as compared to material footprint per capita from 2010 to 2017. This may be because the country lies among the top exporters in the world. In 2015, India's commercial services exports aggregated at USD 158 billion while imports were USD 126 billion.[106] In 2019, India exported a total of USD 330 billion, making it the 15th largest exporter in the world. From 2014 to 2019, the exports of India have increased from USD 320 billion to USD 330 billion in 2019.[107] Moreover, the country's demand for domestic private consumption is mostly fulfilled by domestic manufacturing as nearly 60% of the GDP is driven by domestic private consumption.[108]

106 https://economictimes.indiatimes.com/news/economy/foreign-trade/indias-rank-unchanged-at-19th-among-top-30-exporters/articleshow/51745091.cms?from=mdr
107 https://oec.world/en/profile/country/ind#:~:text=In%202019%2C%20India%20exported%20a,15%20exporter%20in%20the%20world.
108 https://en.wikipedia.org/wiki/Economy_of_India

3.2.1.4 Energy use

In India, the energy demand has increased many folds and the electricity consumption has increased at a 7.39% compound annual rate.[109] This energy demand is coming from all sectors of the economy (i.e., from industrial to agricultural and commercial to residential uses). Furthermore, it is expected that the trend will continue over the coming decades. The industry, residential, and transport sectors consume the maximum energy as shown in **Figure 3-48**. The energy use in the industrial sector has significantly increased (i.e., from almost 30% in 2005 to 39% in 2019); showing positive signs of economic growth in the country. The residential sector has also shown a substantial change (i.e., from almost 48% in 1990 to 25% in 2019) in the final energy consumption. However, the energy consumption patterns in other sectors (e.g., commercial and public, and agriculture/forestry etc.) have remained under 10% during the period of 1990 to 2019.

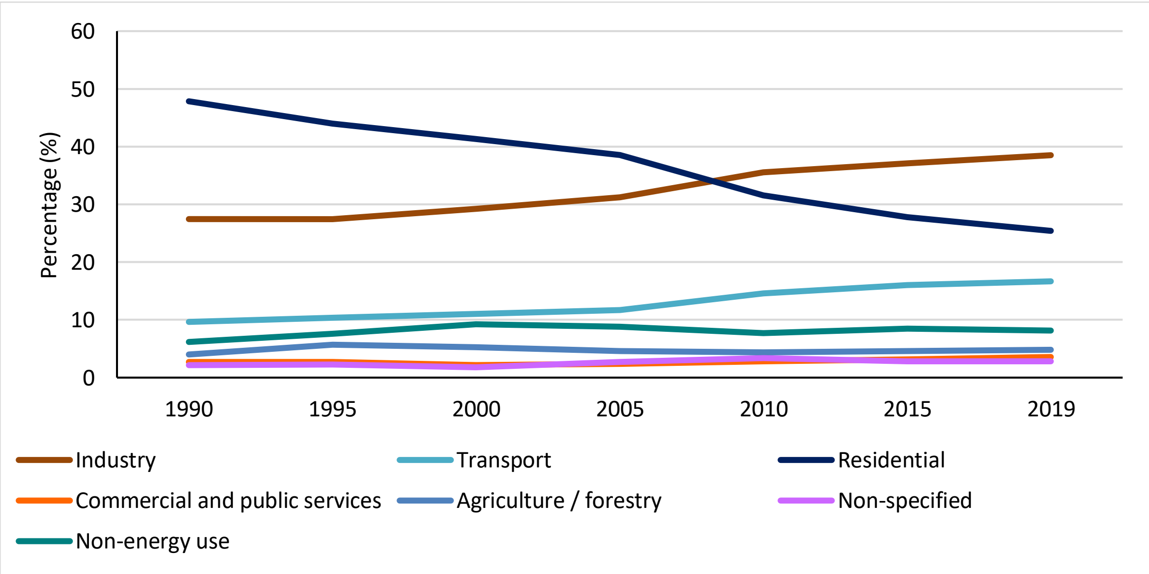

Figure 3-48 Sectoral share in total final energy consumption in India (1990-2019)[110]

[109] NBR. 2021. India's Energy Mix and the Pathways to Sustainable Development. Available at: https://www.nbr.org/wp-content/uploads/pdfs/publications/asia_edge_sahoo_030621.pdf

[110] IEA. (2022). International Energy Agency. Retrieved from: https://www.iea.org/data-and-statistics

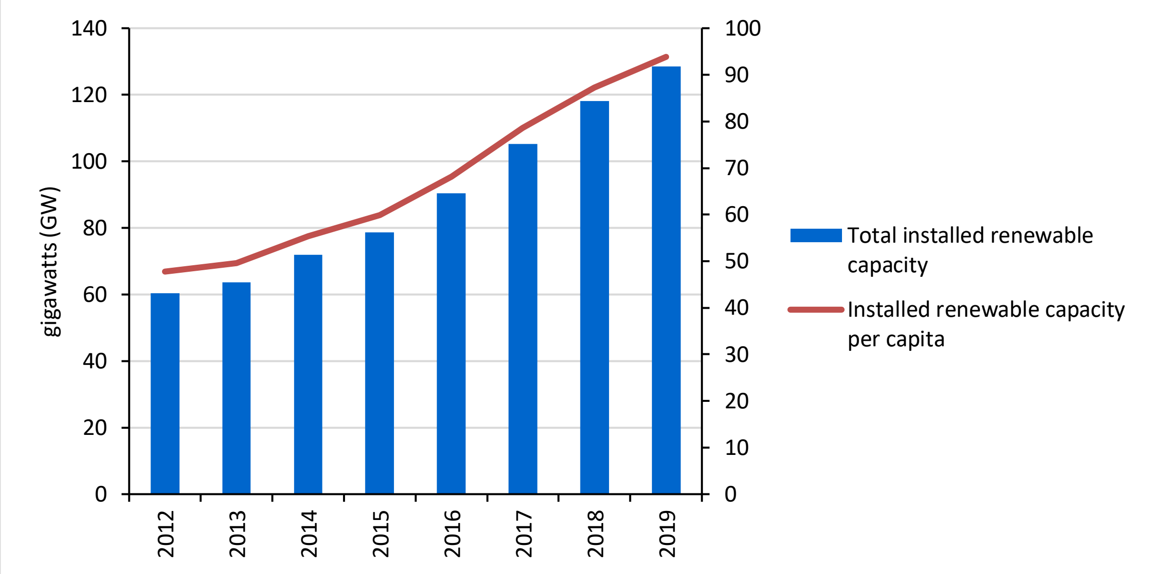

Figure 3-49 Installed renewable electricity-generating capacity in India (2012-2019) [111,112]

Currently, India is endeavoring to enhance the proportion of variable renewables in its energy mix. According to the International Energy Agency (IEA), the share of solar PV and wind energy has been doubled (i.e., from 4% to 8% during 2016 to 2018) in the electricity generation mix. In 2019, more than twenty hydroelectric projects had a combined generating capacity of 45.4 GW[113]. Furthermore, the overall installed renewable electricity generation capacity has been increased from 60 gigawatts to 128 gigawatts during 2012 to 2019 as shown in **Figure 3-49**. India has committed to increase the share of renewable energy up to 50% by 2030 to fulfil its energy requirements[114]. This growth can especially be observed in the solar and wind energy sectors.

The National Action Plan for Climate Change (NAPCC), unveiled in 2008, was initiated by the government with the goal of mitigating and adapting to the adverse effects of climate change. The National Solar Mission, the National Mission for Enhanced Energy Efficiency, and the Green India Mission, were among the eight sub-missions of the action plan. As part of the

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[111] UNEP. (2022). The United Nations Environment Programme. Available at: https://wesr.unep.org/downloader

[112] IRENA (2022).RENEWABLE CAPACITY STATISTICS 2022. *The International Renewable Energy Agency (IRENA)*. Available at: https://www.irena.org/IRENADocuments/Statistical_Profiles/Asia/China_Asia_RE_SP.pdf. [Accessed on April 2022]

[113] NBR. (2021). India's Energy Mix and the Pathways to Sustainable Development. Available at: https://www.nbr.org/wp-content/uploads/pdfs/publications/asia_edge_sahoo_030621.pdf

[114] PMO. (2021). National Statement by Prime Minister Shri Narendra Modi at COP26 Summit in Glasgow. *Prime Minister's Office (PMO)*. Available at: https://pib.gov.in/PressReleasePage.aspx?PRID=1768712

Union's 2021-22 Budget, the Government of India announced an extra capital infusion of nearly 0.13 billion USD (or 10 billion INR) to the Solar Energy Corporation of India (SECI) and about 0.2 billion USD (or 15 billion INR) to the Indian Renewable Energy Development Agency (IREDA).[115] Furthermore, the Renewable Energy Certificates (RECs) mechanism, which was introduced by government in 2011, aimed to quickly expand the percentage of renewable energy in the country's total energy mix. In 2021, the government approved amendments in REC framework in order to revitalize the tradable REC mechanism to align it with the growing changes in the power landscape and boost the renewable energy.[116,117]

Energy intensity

The country's energy consumption has continued to rise due to the expansion of the Indian economy. Shift to more energy-intensive modes of transportation, greater appliance ownership, and expanded floor space of buildings are a few of the structural reasons contributing to an increase in energy demand. In recent years, the Indian government has made significant improvements to enhance the accessibility to power and clean cooking for its citizens. The focus is now moving to energy security, energy efficiency, and energy affordability illustrated by energy market reforms. As India's economy develops, energy efficiency will become more vital in achieving these goals.

[115] IEA. (2021). Renewable energy investment. *International Energy Agency (IEA).* Available at: https://www.iea.org/policies/13075-renewable-energy-investment?q=india%20renewable%20energy&s=1
[116] IEA. (2021). Renewable Energy Certificates system. *International Energy Agency (IEA).* Available at: https://www.iea.org/policies/4816-renewable-energy-certificates-system?q=india%20renewable%20energy&s=1
[117] Das, B. (2021). Renewable Energy Certificates: How new amendments provide safety net to renewable power developers. *DownToEarth.* Available at: https://www.downtoearth.org.in/blog/renewable-energy/renewable-energy-certificates-how-new-amendments-provide-safety-net-to-renewable-power-developers-79483

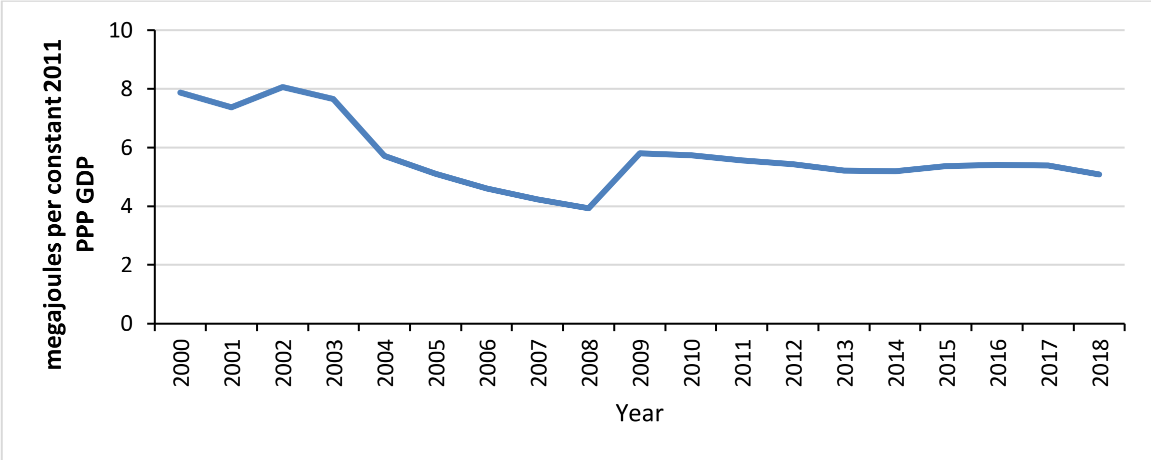

Figure 3-50 Energy intensity of India (2000-2018)

The energy intensity of India has decreased (i.e., 7.9 to 5.1 megajoules per constant 2011 purchasing power parity GDP) from 2000 to 2018 as shown in **Figure 3-50**. According to International Energy Agency, between 2007 and 2017, India's final energy consumption climbed by 50% with growth across all sectors (especially in the industrial and transportation sectors).[118] However, there was a decline in GDP growth after 2007 as shown in **Figure 3-37**. Therefore, a sudden increase in the energy intensity can be observed after 2007 in **Figure 3-50**.

3.2.1.5 Agricultural productivity

Agriculture provides a living for the majority of India's inhabitants, and its significance cannot be overstated. The agriculture industry employs about half of the country's workers. It also accounts for 17.5 percent of the country's GDP (at current prices in 2015-2016).[119] Agricultural production is influenced by a number of variables. Agricultural inputs such as land, water, seeds, and fertilisers, as well as access to agricultural loans and crop insurance, assurance of remunerative pricing for agricultural products, and storage and marketing facilities, are among them.

[118] IEA (2021), E4 Country Profile: Energy Efficiency in India, IEA, Paris https://www.iea.org/articles/e4-country-profile-energy-efficiency-in-india.
[119] *Analytical Reports*. (n.d.). PRS Legislative Research. Retrieved January 20, 2022, from https://prsindia.org/policy/analytical-reports/state-agriculture-india#:~:text=Despite%20high%20levels%20of%20production

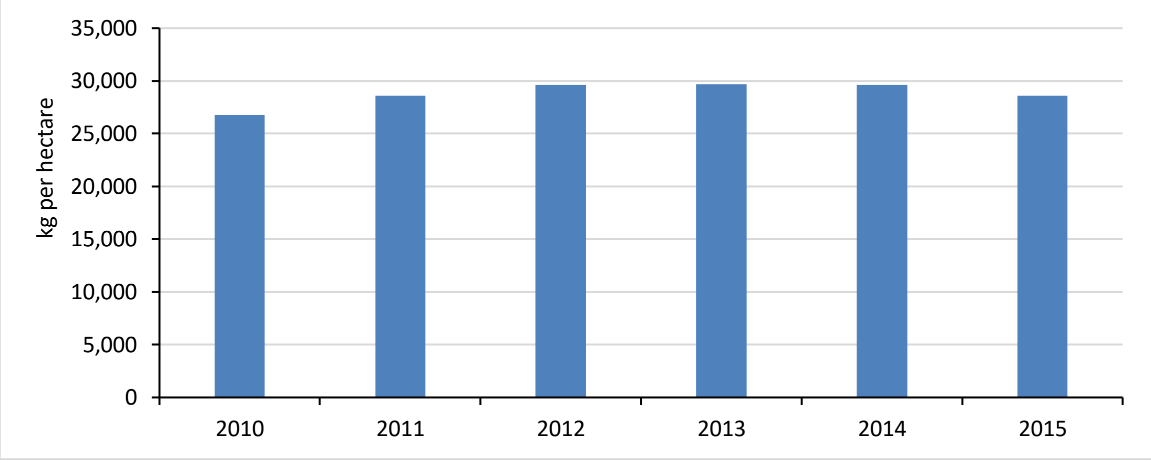

Figure 3-51 Agricultural productivity (cereal yield) in India (2010 - 2015)

With the start of the Green Revolution in India, modern technology has made a huge contribution to increasing agricultural productivity. Every year, India's food grain output rises, and the country ranks among the world's top producers of wheat, rice, pulses, sugarcane, and cotton. Agricultural productivity (growth) has been on the rise over the past decade, until 2014, when it began to drop. As illustrated in**Figure 3-51**, the rise varied from 5.8% in 2005-2006 to 0.4 percent in 2009-2010 before declining to -0.2 percent in 2014-15. However, as compared to other major producing nations such as China, agricultural yield (amount of crop produced per unit of land) is shown to be lower in the case of most crops.

For planners and all other stakeholders, the future of agriculture is a critical issue. The government and other organisations are working to address some of India's most pressing agricultural issues, such as smallholder farming, primary and secondary processing, supply chains, infrastructure that supports efficient resource use, and marketing by decreasing market middlemen. It is necessary to work on cost-effective solutions that protect the environment and conserve our natural resources.

3.2.1.6 Greenhouse gas emission

Despite being one of the first countries to sign the Paris Climate Agreement in 2015, India is now the world's third largest producer of greenhouse emissions, after only China and the United States. GHG emissions are growing rapidly due to significant sources such as coal power stations, rice fields, and livestock. Carbon dioxide is created as a result of the combustion of solid, liquid, and gas fuels, as well as gas flaring. India has also been taking concrete actions to honour its commitment to the Paris Climate Agreement, notably by reducing GHG emissions and reducing intensity.

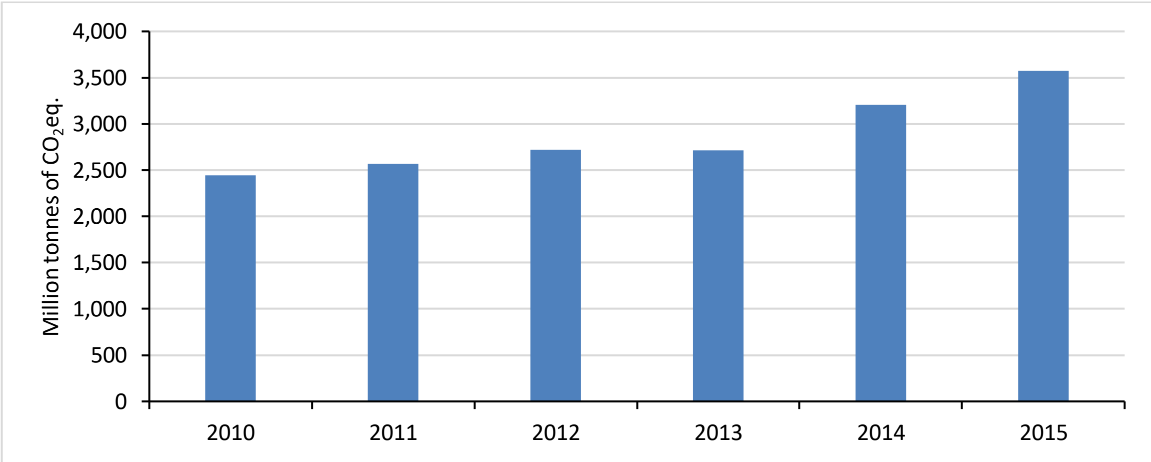

Figure 3-52 Total GHG emissions in India (2010 - 2015)

As shown in **Figure 3-52**, India's total GHG emissions in 2014 were 3,202 million metric tonnes of carbon dioxide equivalent (Mt CO_2eq) and climbed to 3,571 Mt CO_2eq in 2015. Long-term growth initiatives for 2030-2045 are being considered by the Indian government, which would "decouple" carbon emissions from economic development. The Indian government vowed at the COP26 conference to reduce the country's total anticipated carbon emissions by 1 billion tonnes between now (3,571 Mt CO_2eq) and 2030.

Greenhouse gas from energy use

The energy sector accounts for 68.7% of GHG emissions in India, followed by agricultural, industrial processes, land-use change and forestry, and garbage, which account for 19.6%, 6.0 percent, 3.8 percent, and 1.9 percent, respectively. **Figure 3-53** shows that GHG emissions from the energy sector have been rising since 2010.

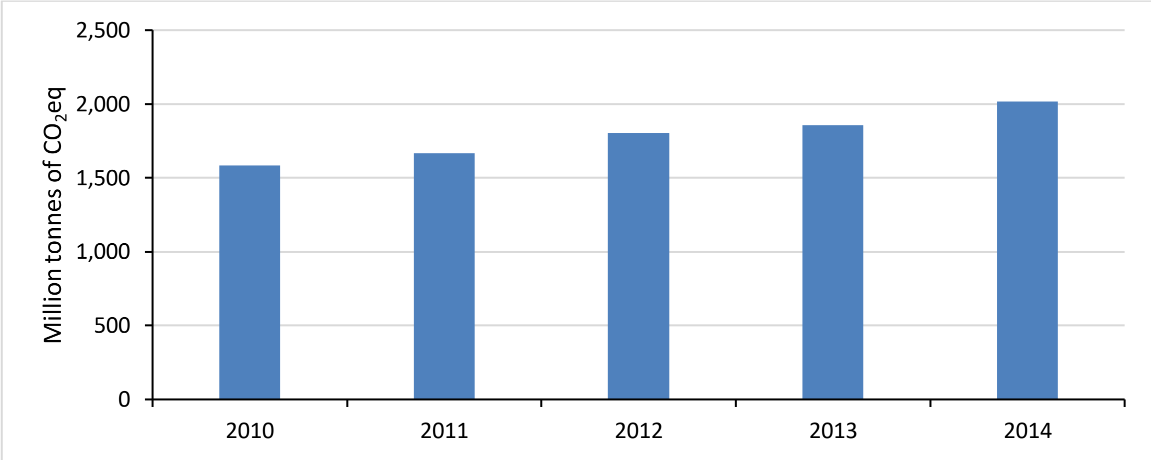

Figure 3-53 GHG emissions from energy use in India (2010 - 2015)

Emissions from power usage and fugitive emissions are the two primary energy-related emissions studied in this industry. Fugitive emissions are the unintended or purposeful releases of greenhouse gases that occur during the extraction, production, processing, or transportation of fossil fuels.[120] India planned to attain electric power installed capacity of roughly 40% from non-fossil fuel-based energy resources by 2030 through technology transfer and low-cost foreign funding in order to reduce emissions from electricity generation. This would result in an extra carbon sink of 2.5 to 3 billion tonnes of CO_2eq by 2030, as well as a framework for the rapid dissemination of cutting-edge climate technology in India and cooperative collaborative research and development for future innovations.

Greenhouse gas in the agriculture sector

Agriculture is the second largest contributor of GHG emissions with a share of more than 18% in India. Agricultural activities, since India is widely known for being an agriculture-dominated country, contribute directly to greenhouse gas emissions through a number of processes. Methane (CH_4) emissions from irrigated rice cultivation, nitrous oxide (N_2O) emissions from the use of nitrogenous fertilisers, and the release of GHG from energy sources used to pump groundwater for irrigation are the main agricultural sources of GHGs.

[120] IPCC, (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Prepared by the National Greenhouse Gas Inventories Programme, Eggleston

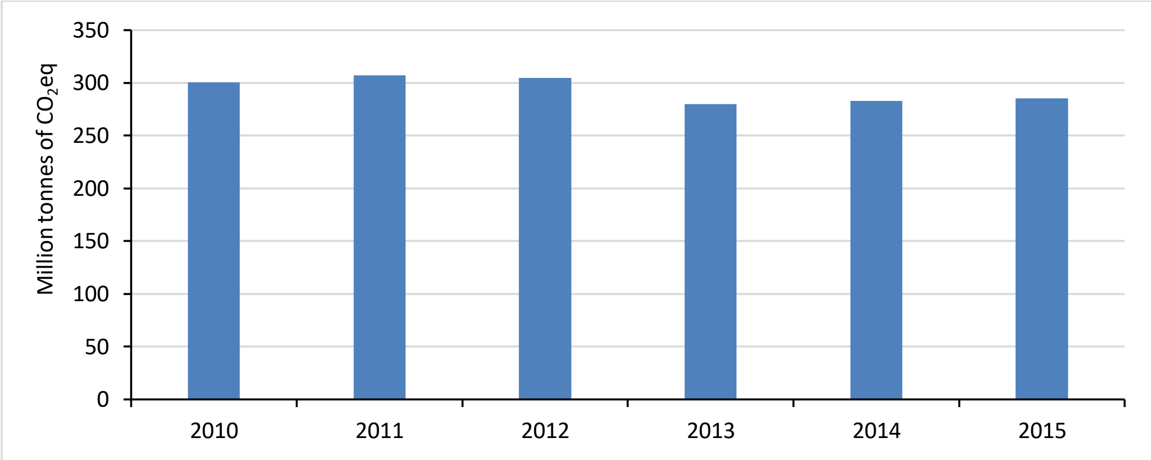

Figure 3-54 GHG from agriculture in India (2010 - 2015)

Open burning, which is often connected with agricultural operations, also adds to greenhouse gas emissions. The majority of agricultural GHG emissions in India occur during the primary production stage, and are caused by agricultural input production and usage, farm machinery, soil disturbance, residue management, and irrigation.[121] Indian agriculture has become more GHG-intensive as a result of increased usage of agricultural inputs such as mineral fertiliser.

Greenhouse gas intensity

The total quantity of greenhouse gas emissions emitted per unit of GDP is known as GHG emission intensity. It includes emissions other than those connected to energy (for example, emissions from agriculture) and greenhouse gases other than carbon dioxide (such as methane). It is determined by the fuel mix (energy sector GHG intensity) and energy intensity. The country with the lowest carbon intensity would theoretically be the one that utilises the least fossil energy in its fuel mix and has the best energy intensity—depending on the economy's composition.

[121] Pathak H., Jain N., Bhatia A., Patel J., Aggarwal P.K. Carbon footprints of Indian food items. *Agric. Ecosyst. Environ.* 2010;**1–2**:66–73.

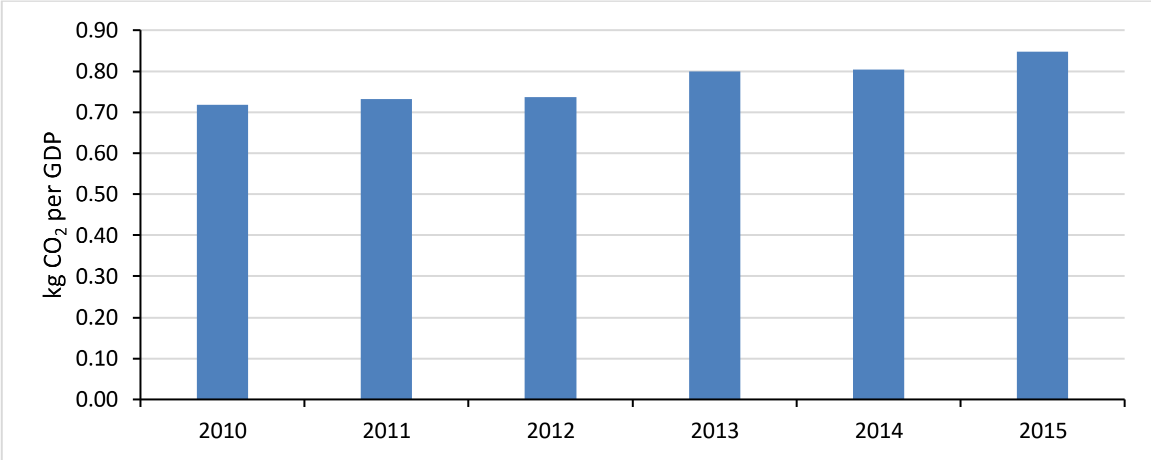

Figure 3-55 GHG emissions intensity in India (2010 - 2015)

Between 1990 and 2014, India's GDP expanded by 357 percent, but its GHG emissions climbed by 180 percent. India, on the other hand, has taken substantial strides toward establishing a low-carbon economy in several sectors and vowed to reduce GDP emissions intensity in its Intended Nationally Determined Contribution (INDC). At the COP26, India announced emission reduction promises that would benefit the country in the long run with new energy efficiency and green fuel technologies that are predicted to lower intensity by 45 percent by the end of the decade and achieve net-zero carbon emissions by 2070.

3.2.1.7 Material use and HDI

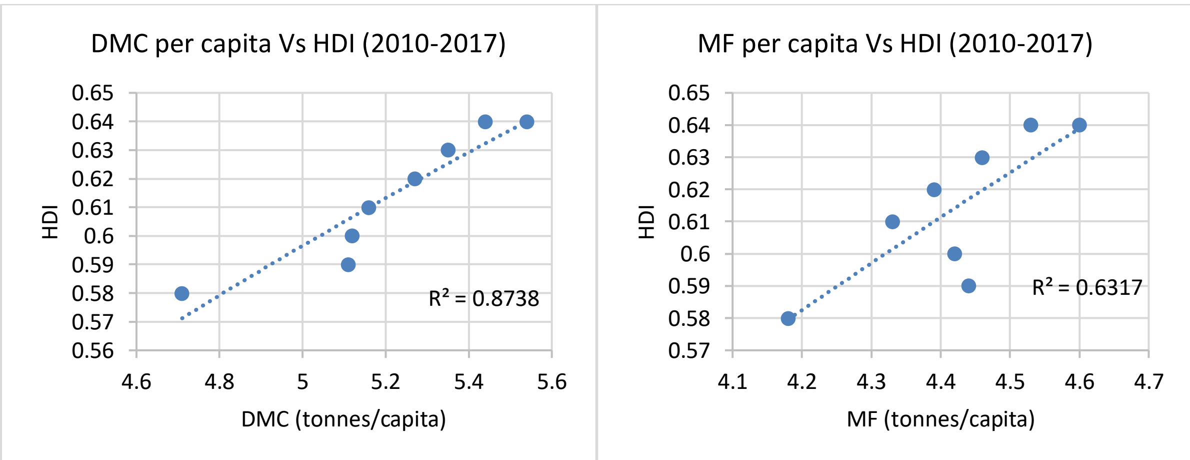

Figure 3-56 The relationship between material use (DMC per capita), and material footprint (MF per capita) versus the human development index (HDI) for India (2010-2017).

Figure 3-56 shows the relationship between DMC and HDI, and the relationship between the material footprint of consumption and HDI in India from 2010 to 2017. It can be seen from **Figure 3-56** that the correlation between DMC and HDI is much stronger as compared to material footprint as indicated by the values of correlation coefficient "*r*" between DMC and HDI, and material footprint and HDI which were 0.9406 and 0.7962, respectively, from 2010 to 2017. From the three dimensions of HDI, life expectancy ratio and literacy rate can be improved by minimum material consumption, while improved living standard which is measured in terms of income level (GNI/capita) is always associated to the increase in material and other natural resource consumption. According to the "Income and Employment Theory" income is directly related to employment generation, and to understand the relationship between HDI and material consumption one can use level of employment creation by material intensive sectors.[122] In case of India construction sector is most material intensive sector (see **Figure 3-44** for reference), while the agriculture sector provides the largest share of employment in the country. However, even though the share of the country's workforce in agriculture has decreased, it still provided an average of around 47% of employment from 2009 to 2019. After agriculture, services and manufacturing industry are the second and third major sectors, respectively, in terms of employment creation.[123] The absence of construction sector among the top employment providing sectors can be the reason behind comparative weaker relationship between material footprint and HDI.

[122] https://www.encyclopedia.com/social-sciences/applied-and-social-sciences-magazines/income-and-employment-theory

[123] https://www.statista.com/statistics/271320/distribution-of-the-workforce-across-economic-sectors-in-india/

3.2.1.8 Material use and economic growth

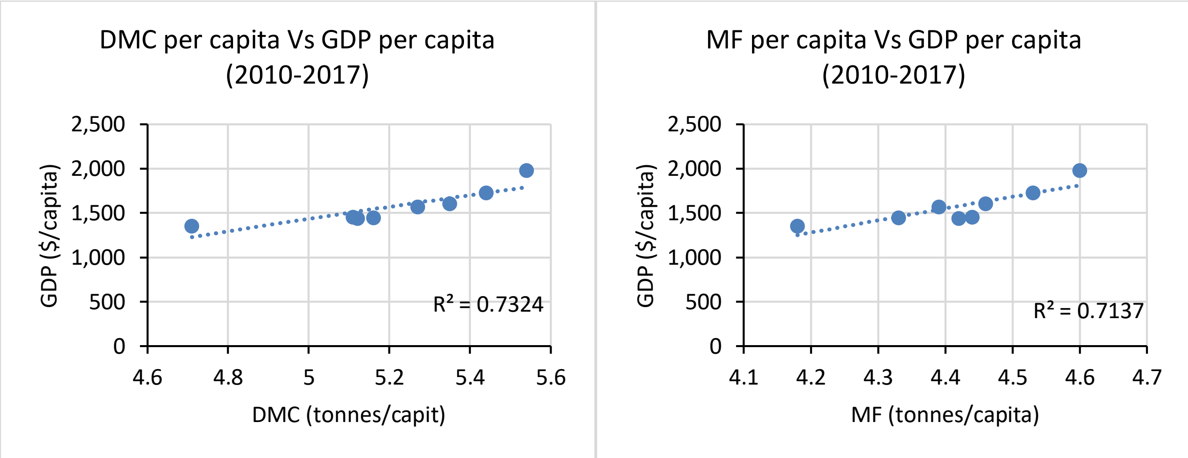

Figure 3-57 The relationship between material use (DMC per capita), and material footprint (MF per capita) versus the GDP per capita, India (2010, 2017)

In **Figure 3-57**, India's DMC per capita (tonnes/capita) and material footprint per capita (tonnes/capita) are plotted against GDP per capita for 2010 and 2017. It can be seen that both DMC per capita and material footprint per capita have a positive and very strong relationship with GDP per capita. However, for India, the correlation between DMC and GDP is slightly stronger as compared to material footprint and GDP as the value of correlation coefficient "*r*" between DMC and GDP, and material footprint and GDP was 0.8694 and 0.8520, respectively, from 2010 to 2017.

Waste management

Saahas provides innovative solutions towards the design of eco-products by recovering valuable resources from waste; it promotes reduced use of natural resources and prevents debris from going to the landfill. Simplistically speaking, this would address half of the total waste problem.

Saahas Zero Waste decentralized design systems have focused on implementing solid waste management rules such as segregation at source, onsite management of biodegradable waste, and transportation of non-biodegradable waste for further sorting of its materials recovery facility (MRF). The non-biodegradable waste is sorted into more than 20 categories, baled and sent to recycling facilities and cement kilns for co-processing. This system ensured that less than 5% of the total solid waste generated at the generator's premises is sent to landfills, therefore, solving the issues of open burning and dumping of the waste, emissions to water bodies, and improper landfill causing hazardous emission to air, water, and soil. Saahas Zero Waste enhanced the resource use efficiency by recovering the resources from the waste through processing it in a closed-loop system (i.e., recovering resources from the waste such as compost, biogas, recycled products etc.).

The main achievement of the company is obtaining a 98% recovery rate of waste materials collected from SZW's customers. *In 2020, the GHG emissions were reduced by around 37,000 tonne CO_2eq from the avoidance of landfilling and open burning of waste.* The other notable contributions of the company are direct employment to 252 field staff from the base of the pyramid. Given that they are its permanent employees, SZW can provide them dignified livelihoods, statutory wages, social security benefits and ensure the maintenance of stringent environmental, health and safety standards. As per an independent social impact survey carried out at SZW, employees have had several benefits after joining SZW, such as (i) the household income has increased by 105% on an average, and (ii) the regularity of income has allowed the employees to buy both utility and productive assets that have improved their quality of life.

3.2.1.9 Physical Trade Balance

Agricultural sector

India is a net exporter for the agricultural sector (**Figure 3-58**). The major exported crops are Basmati rice, other rice, and cotton[124]. The growth of exported crops quickly climbed from 2011 to 2013. Exported crops stayed constant at a share of around 90% from 2010 to 2017 with an average growth of 12%. Conversely, the exports of crop residues and grazed biomass and fodder crops dropped significantly on average by 51% and 43%, respectively. These

[124] Department of Commerce. (2021). *Export Products (Agriculture)*. Ministry of Commerce and Industry, Government of India. https://commerce.gov.in/about-us/divisions/export-products-division/export-products-agriculture/.

resulted from Indian government support in the agricultural sector such as enhancing public sector investment in research and transferring of technology including financial support to farmers[125]. India doubled their per capita physical trade balance from -0.007 tonnes per capita in 2010 to -0.02 tonnes per capita in 2017, as shown in **Figure 3-59**.

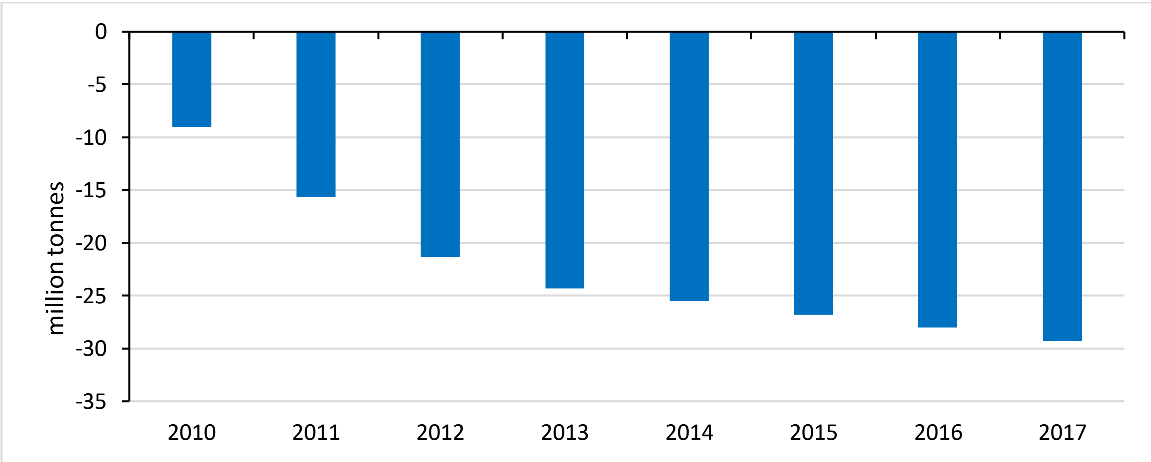

Figure 3-58 Physical trade balance by the agricultural sector in India, 2010 to 2017

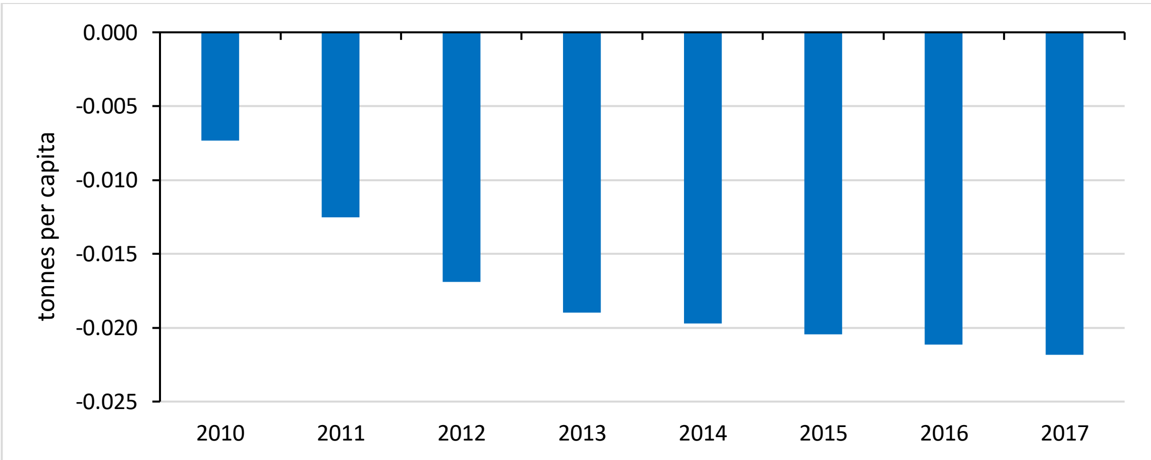

Figure 3-59 Physical trade balance per capita by the agricultural sector in India, 2010 to 2017

[125] CSE (*2012). State of Indian agriculture 2011-12* .Centre for Science and Environment, Ministry of Agriculture . http//:www.indiaenvironmentportal.org.in/content/350144/state-of-indian-agriculture-2011-12/

Food sector

As shown in **Figure 3-60**, India experienced a sharp increase in its deficit of the food sector in 2011 which was mainly driven by Indian government support such as financial support of agriculture and open market sales[126]. The deficit stayed relatively constant after 2013. The exported and imported food grew by an average of 12% and 9%, respectively. In 2017, the crops were the main exported food which accounted for 98% of the total while the remaining was from wild catch and harvest. India tripled its physical trade balance per capita from -0.008 tonnes per capita in 2010 to -0.023 tonnes per capita in 2017 (**Figure 3-61**).

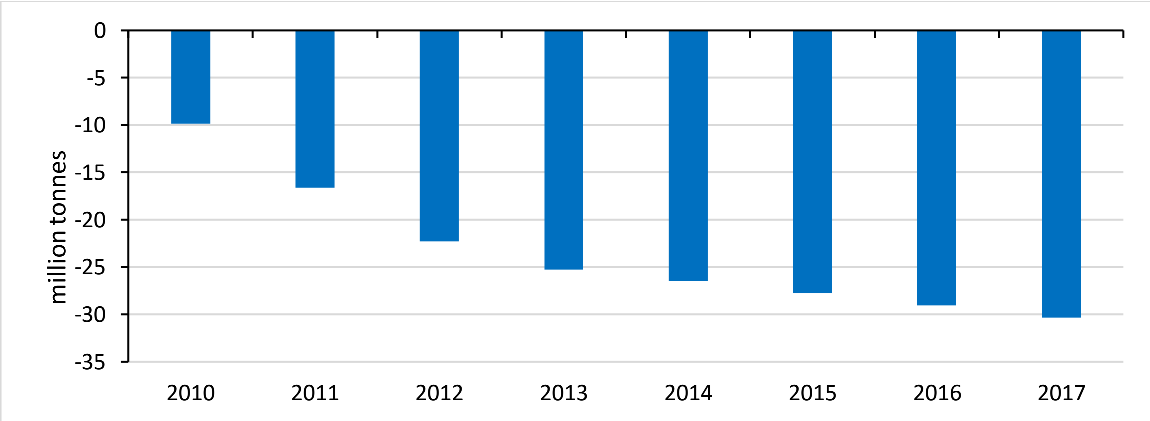

Figure 3-60 Physical trade balance by food sector in India, 2010 to 2017

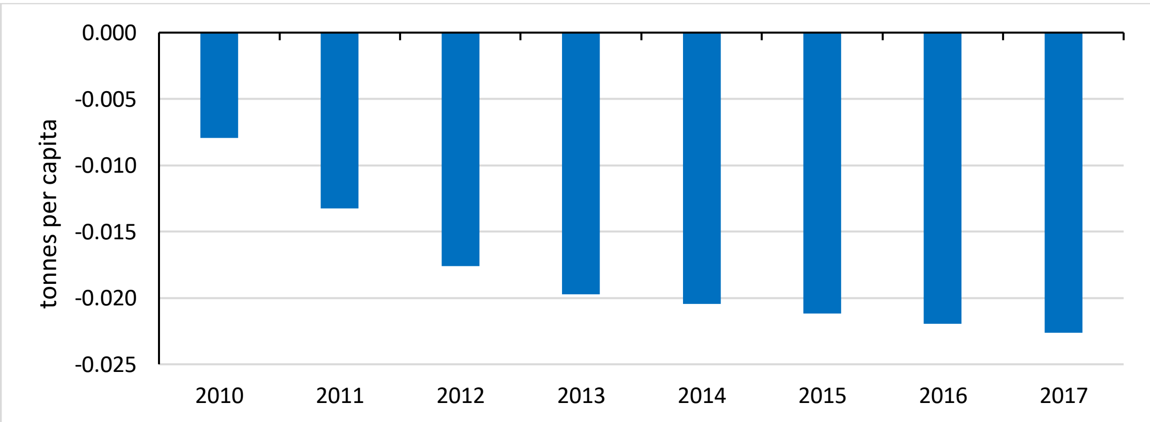

Figure 3-61 Physical trade balance per capita by food sector in India, 2010 to 2017

[126] Mustard, A. (2014) *Government Fiscal Support of Agriculture, GAIN Report Number :IN4044* .USDA's Foreign Agricultural Service, Global Agriculture Information Network . https//:apps.fas.usda.gov/newgainapi/api/report/downloadreportbyfilename?filename=Government%20Fiscal%20Support%20of%20Agriculture_New%20Delhi_India_6-10-2014.pdf

Construction sector

India's trade surplus in the construction sector faced fluctuation from 2010 to 2012, as shown in **Figure 3-62**.[127] Rapid rise in exports (i.e., 66% in 2011) due to foreign trade policy could be a possible reason which made the export of limestone, lime shell, and chalk free. Growth in both exports and imports remained constant since 2015 at 3% and 6%, respectively. The physical trade balance per capita was 0.01 tonnes per capita in 2017 which increased by 26% from 2010 (**Figure 3-63**).

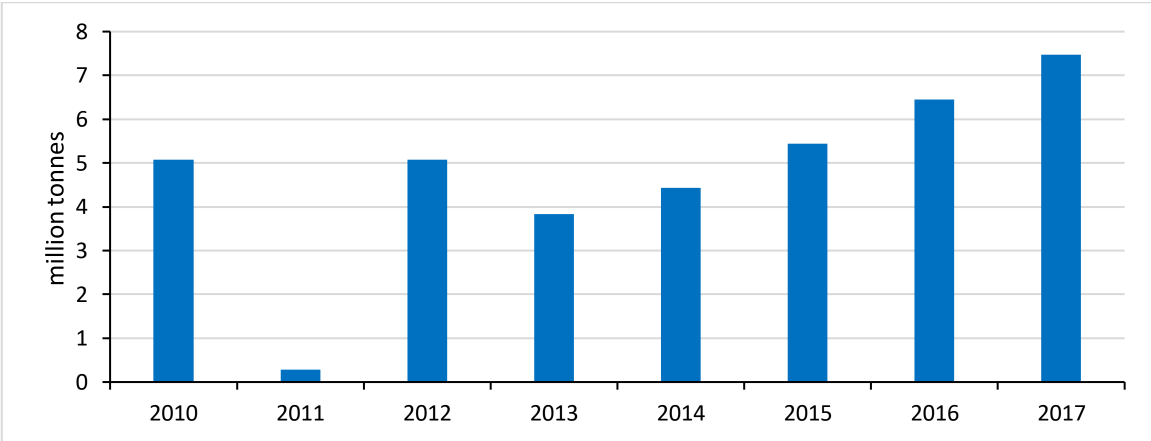

Figure 3-62 Physical trade balance by the construction sector in India, 2010 to 2017

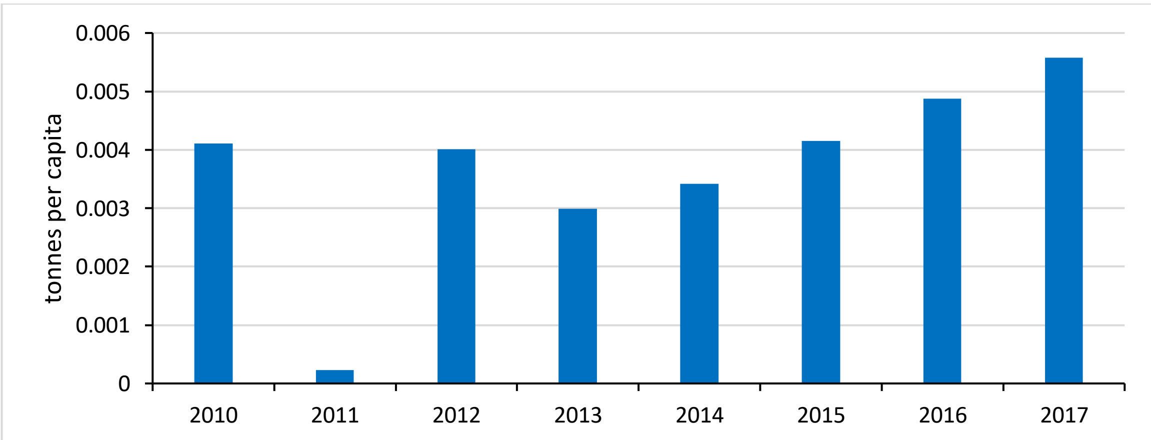

Figure 3-63 Physical trade balance per capita by the construction sector in India, 2010 to 2017

127IBM (2014). *Indian Minerals Yearbook 2012Part -III :Mineral Reviews* .Ministry of Mines, Government of India . https//:ibm.gov.in/writereaddata/files/07092014125621IMYB_2012_Limestone%20and%20other%20calcareous%20Materials.pdf

3.2.2 Consolidated discussion

India's consumption and production patterns have increased significantly in recent decades, causing resource depletion and pollution, far beyond the ecosystem's regenerative and assimilative potential. As a result, local (like resource shortages) and global (like biodiversity loss and climate change) challenges have evolved or gotten worse. On the other hand, decreased availability of resources is posing serious threat to the major sectors, especially the industrial and agriculture which are the largest contributor to economy of the country. Furthermore, a comprehensive summary of SCP indicators and issues considering the DPSIR framework for India is presented in **Table 3-3**.

Table 3-3 A summary of SCP indicators and issues considering the DPSIR framework for India.

Derivers/ pressures	State/ impact	Responses
- Increasing population (0.8 billion to 1.38 billion from 1990 to 2020) - Urban population have increased from around 25% in 1990 to 35% in 2020 - Increased economic activity (per capita GDP raised from almost 300 USD in 1990 to 2100 USD in 2020 and total GDP climbed from 0.3 trillion to 2.6 trillion between 1990 to 2020) - Massive industrialization after the year 2000 has caused the rapid increase in economic growth	- Domestic material consumption increased from 5.8 billion tonnes in 2010 to around 7.4 billion in 2017. - Per capita DMC reached 5.54 tonnes per capita in 2017 from 4.71 tonnes per capita in 2010. - The overall installed renewable electricity generation capacity has been increased from 23.7 watts per capita to 93.9 watts per capita during 2000 to 2019. - Agriculture sector is the major contributor to land use and water use • land use of the agriculture sector was almost constant, i.e., in 1990 the land use of the agriculture sector was 78.51	- Draft National Resource Efficiency, National Action Plan for Climate Change (NAPCC), and Renewable Energy Certificates (RECs) system are among the key policies aimed at achieving ecologically sustainable and fair economic growth, resource security, a healthy environment (air, water, and land), and restored ecosystems with rich ecology and biodiversity in the future. - The concepts of resource efficiency helped to outline the draught National Resource Efficiency Policy. ○ reduction in primary resource consumption to 'sustainable'

Derivers/ pressures	State/ impact	Responses
	million hectares which were increased by 2.7 million hectares by the end of 2018. • Water use of the agriculture sector was increased from 189 billion cubic meters in 2010 to 203 billion cubic meters in 2018 with the rate of 4.08 billion cubic meters per year. - In 2015, the country's GHG emissions rose to 3,571 Mt CO_2eq from 3,202 Mt CO_2eq in 2014. ○ energy sector (68.7%), ○ Agriculture (19.6%), ○ industrial processes (6.0%), ○ land-use change and forestry (3.8 %), and ○ waste (1.9%) - The material intensity of India decreased by around 20%, during 2010 to 2017. - The energy intensity of India has also been decreased from 7.9 to 5.1 megajoules per constant 2011 PPP GDP during 2000 to 2018. - India pledged to reduce GDP emissions intensity by 33-35% by 2030 from 2005 levels.	levels in order to meet the SDGs and stay within planetary boundaries ○ creation of higher value with less material through resource efficient and circular approaches ○ waste minimization ○ material security and creation of employment opportunities and business models that benefit the cause of environmental protection and restoration. - Improving the economy in order to achieve inclusive and long-term growth (while focusing the major sectors such as industrial, agriculture, and transportation).

Derivers/ pressures	State/ impact	Responses
	- Physical trade balance is negative for all the considered sectors except construction. - Agricultural productivity has been volatile over the past decade, ranging from 5.8% in 2005-06 to 0.4% in 2009-10 and -0.2% in 2014-15. - The material footprint of the country was more than 5.5 billion tonnes in 2013 that increased to more than 6 billion tonnes in 2017. - India has a higher DMC per capita as compared to material footprint per capita from 2010 to 2017. - Furthermore, DMC per capita and material footprint per capita has a positive and very strong relationship with GDP per capita	

3.3 Indonesia

- Indonesia is the world's largest island and the fourth most populous country.
- It is one of the largest exporters of agricultural products and the agricultural sector is the major contributor to land use and water use.
- As a result of massive industrialization, its GDP has climbed from 0.1 trillion USD in 1990 to 1.1 trillion USD in 2020.
- Different plans have been introduced to combat the negative environmental impacts, such as Long-Term Strategy for Low Carbon and Climate Resilience 2050.

Indonesia is a major producer of agricultural products in the world and its economy is mainly dependent on industry and agriculture commodities. The increase of material use, energy use, and GHG emissions are triggered by increasing in population and economic growth. However, the in- depth analysis of Indonesia's profile is presented through the DPSIR framework as shown in **Figure 3-64**.

Generally, Republic of Indonesia (namely Indonesia) is the world's largest island country with covering 1,904,569 km^2. Indonesia is also called "Nusantara" since it is located between two continents (the Asian and Australian continents) and two oceans (the Pacific and Indian). Indonesia is the world's fourth most populous nation since the early 21st century. The population of Indonesia was around 181.41 million people in 2020 which increased from 173.52 million people in 1990 as shown in **Figure 3-65**. Indonesia's population rose by 1.07% compared to the previous year. GDP in Indonesia was worth around 1,058.42 billion US dollars in 2020 (see **Figure 3-66**), which its GDP annual growth rate was averaged 4.72% from 1990 to 2020. However, due to the COVID-19 pandemic the economy faced a collapse especially in transportation and accommodation. The government announced fiscal and monetary policies for the recovery and also planned to raise revenues by increasing tax rates such as carbon tax.[128]

[128] OECD (2021). *Indonesia Economic Snapshot*. https://www.oecd.org/economy/indonesia-economic-snapshot/

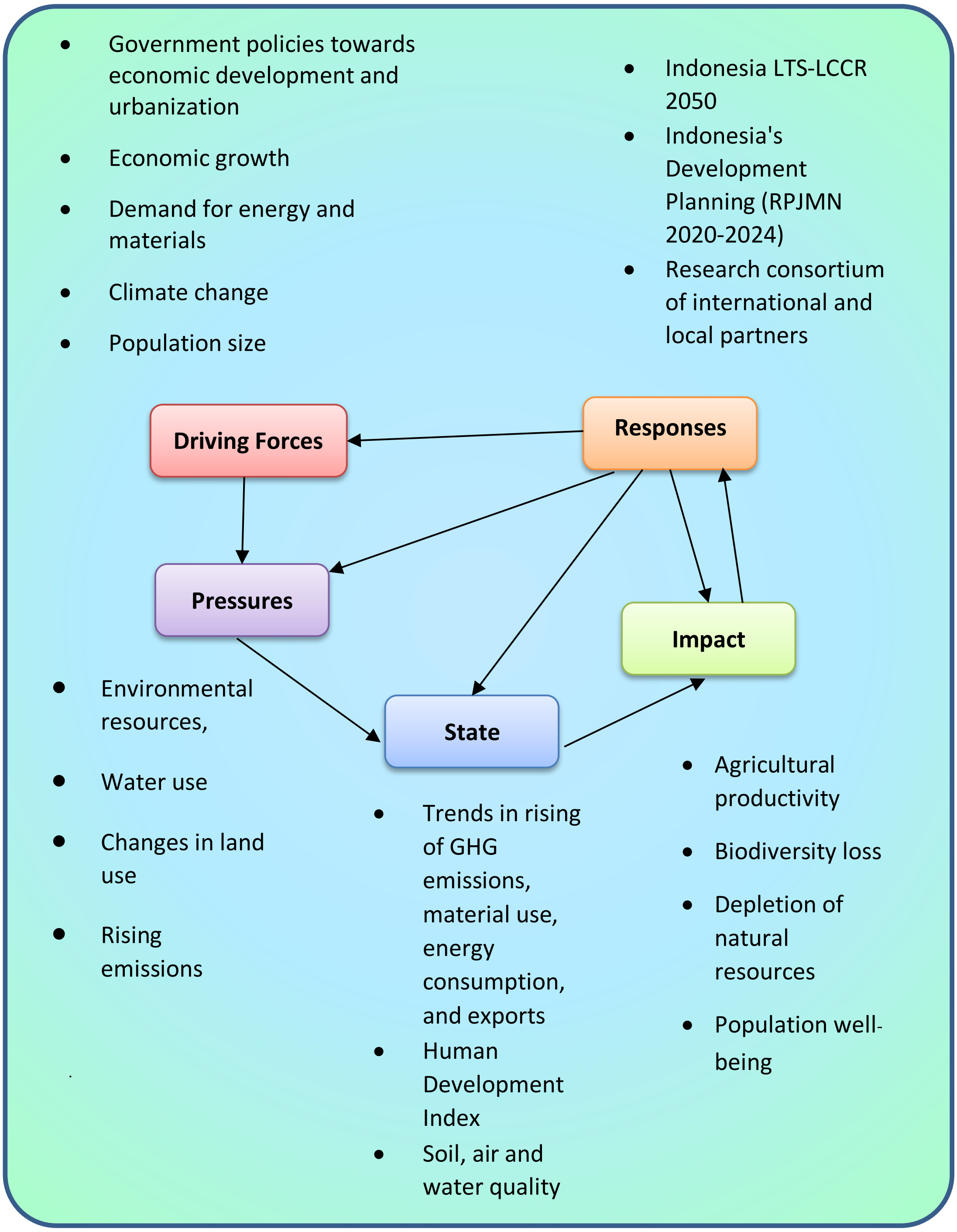

Figure 3-64 DPSIR framework for Indonesia

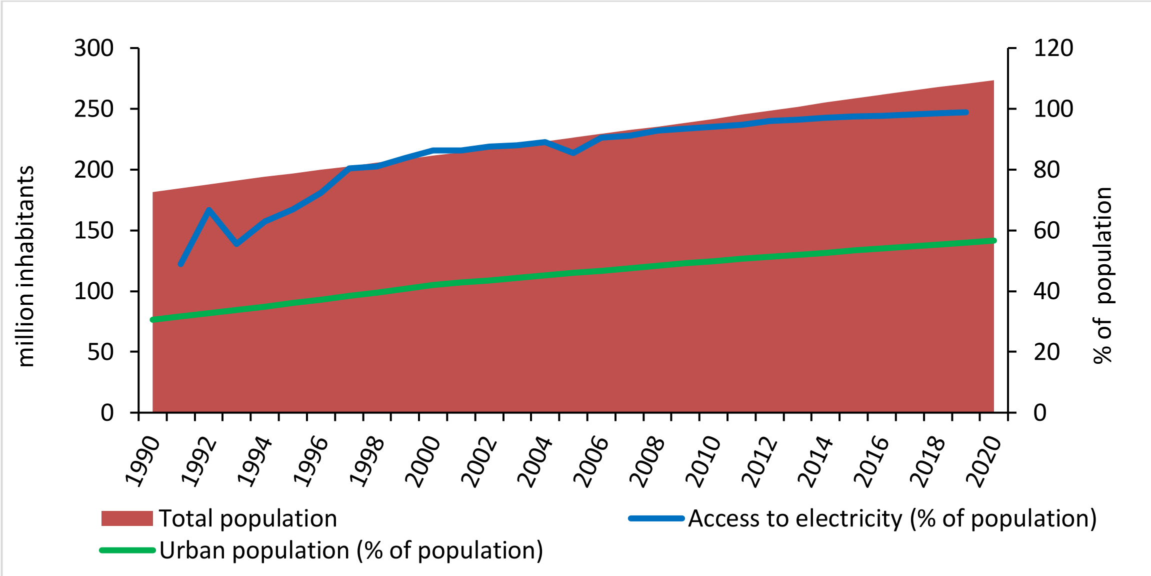

Figure 3-65 Total population of Indonesia, urban population and population having access to electricity[129]

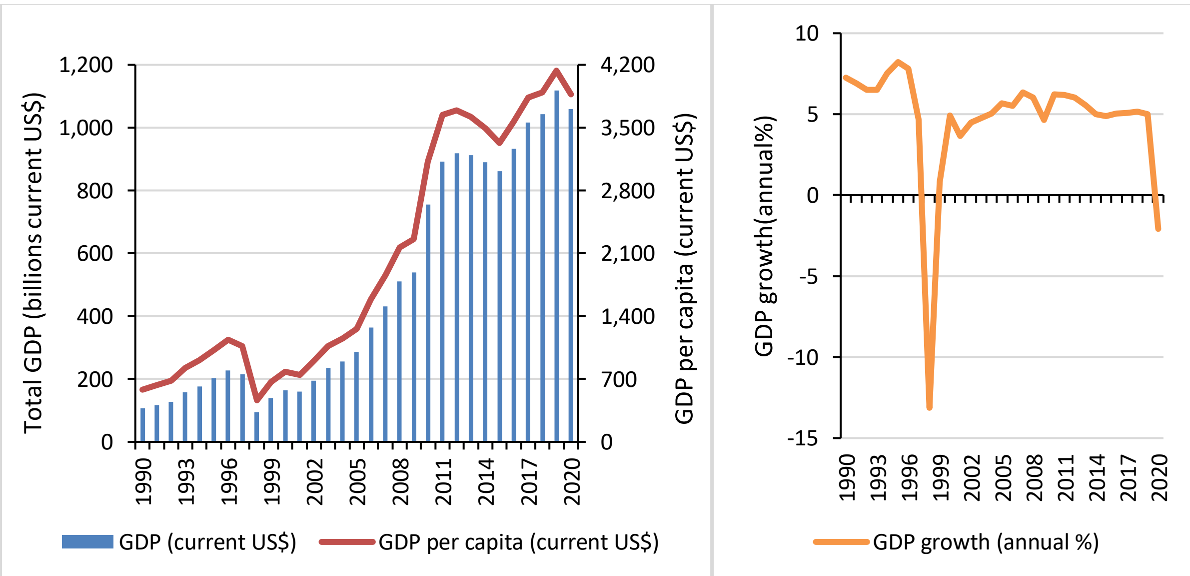

Figure 3-66 Total GDP, GDP per capita, and GDP annual growth of Indonesia [130]

[129] The World Bank, World Development Indicators (2020). Retrieved on, February 3, 2022, from https://data.worldbank.org/indicator

[130] The World Bank, World Development Indicators (2020). Retrieved on, February 3, 2022, from https://data.worldbank.org/indicator

3.3.1 Indicators

3.3.1.1 Water use

The total water use of Indonesia increased by almost 28 billion cubic meters from 2010 to 2017. Overall, it was increased with the rate of 3.88 billion cubic meters annually from 2010 to 2017. In terms of percentage, total water use of Indonesia increased by almost 15 percent from 2010 to 2017. The rapid in total water use is more likely due the significant increase in the economic activities and increase in population of Indonesia. The time series of total water use of Indonesia from 2010 to 2017 is shown in **Figure 3-67**.

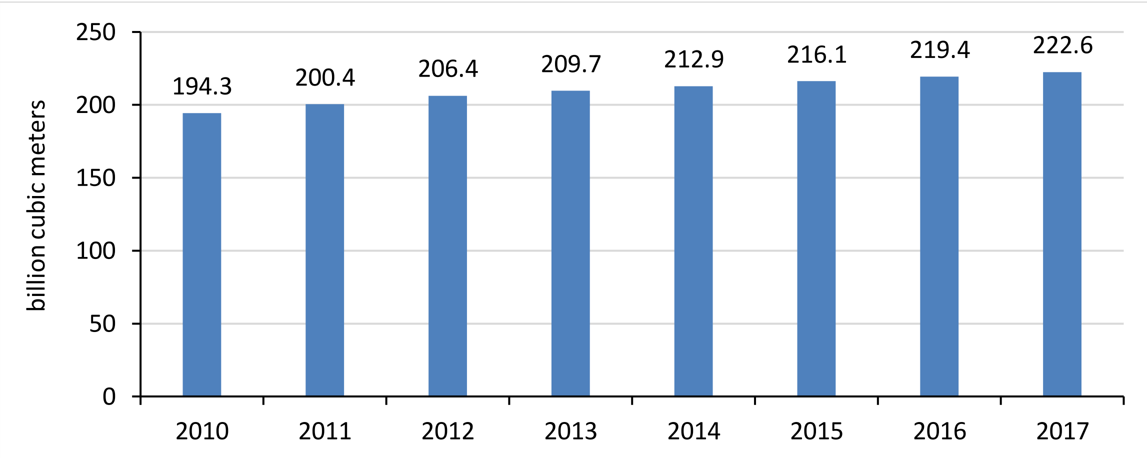

Figure 3-67 Total water use of Indonesia (2010-2017)

<u>**Water use per capita**</u>

The water use per capita of Indonesia increased by almost 38 cubic meters per capita from 2010 to 2017. Overall, it was increased significantly with the rate of 4.6 cubic meters per capita annually from 2010 to 2017. In terms of percentage, total water use per capita of Indonesia increased by almost 3 percent from 2010 to 2017. The noticed increase in water use per capita perhaps due to the rapid increase in industrialization, economic activities, and population. The time series of total water use of Indonesia from 2010 to 2017 is shown in **Figure 3-68**.

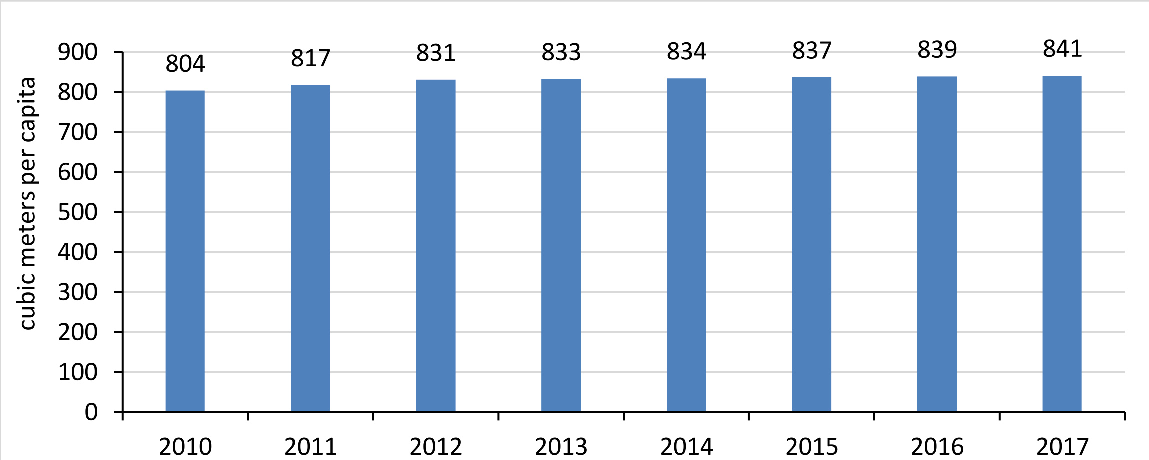

Figure 3-68 Total water use per capita of India (2010-2017)

Total water use intensity

The total water use intensity of Indonesia was showed an oscillating trend from 2010 to 2017. In 2010, the total water use intensity of Indonesia was 0.257 cubic meter per dollar annually, decreased by 11 percent until 2017. Overall, it was decreased with the rate of 0.0015 cubic meter per dollar from 2010 to 2017. In terms of percentage, total water use intensity of Indonesia decreased by almost 15 percent from 2010 to 2017. The decrease in the total water use intensity of Indonesia is probably due to the decoupling efforts of the policymakers. However, the sharp decline in total water use intensity was noticed from 2011 to 2014, which possibly due to the drop in national GDP in the same time. The time series of total water use intensity of Indonesia from 2010 to 2017 is shown in **Figure 3-69**.

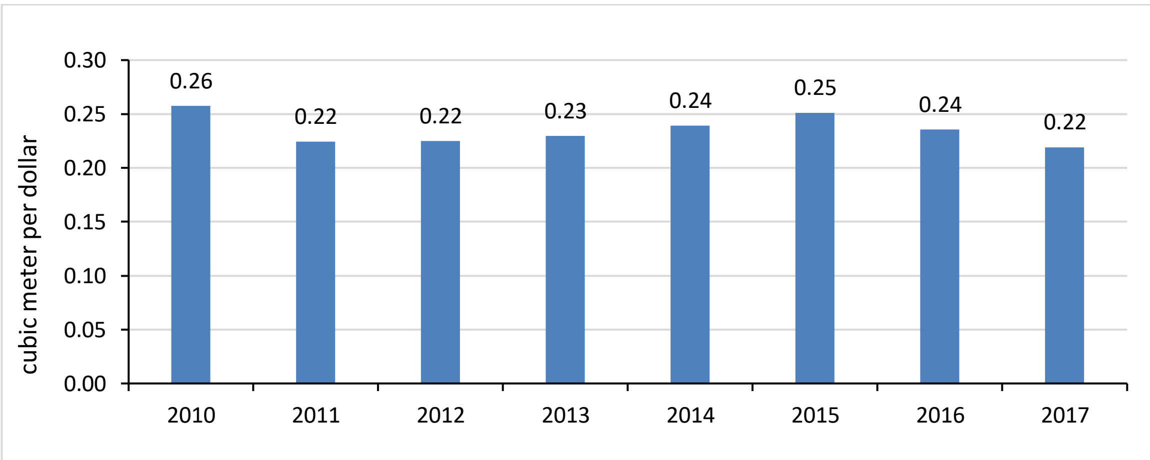

Figure 3-69 Total water use intensity of Indonesia (2010-2017)

Water footprint in major sectors

Water footprint of agriculture sector

Water use footprint in agriculture sector deals with the water use by food crops (wheat, maize, cereals etc.), oil, fiber, non-perennial, spices, aromatic, drug and pharmaceutical, crops beverage crops perennial crops, plant propagation, and water use in livestock farming based on consumption footprint[131]. The water use footprint in the agriculture sector of Indonesia was decreasing from 2010 to 2018. In 2018, the total water use footprint in Indonesia was 3.59 billion cubic meters per year. Overall, it was decreased with the rate of 0.044 billion cubic meters per year from 2010 to 2018. This decrease in water use footprint of agriculture sector is a proof of decoupling evidence as the land use footprint in the agriculture sector was increased during this period. It is due to the use of modern efficient techniques of irrigation or change in crop types. The time series of water use footprint in the agriculture sector of Indonesia from 2010 to 2018 is shown in **Figure 3-70**.

Water footprint of food sector

Water use footprint in food sector deals with the water use by processing, preserving, and manufacture of meat and fish-based products, cereal-based products, food crop product, mixed food and feed, cocoa, fiber-based products, chocolate and sugar confectionery, vegetable and animal oils and fats, and manufacture of dairy products, alcoholic and other beverages, tobacco products based on consumption footprint[132]. Water use footprint in the food sector of Indonesia was showing an increase in trend. In 2010 the water use footprint of the food sector in Indonesia was 0.79 billion cubic meters that was increased by 0.06 billion cubic meters by the end of 2018. Overall, it was increased with the rate of 0.006 billion cubic meters per year from 2010 to 2018. The highest water use footprint in the food sector was noticed in 2018 i.e., 0.134 billion cubic meters. The increase in water use footprint in the food sector is possibly due to the population expansion. The time series of water use footprint in the food sector of Indonesia from 2010 to 2018 is shown in **Figure 3-70**.

[131] SCP-HAT (http://scp-hat.lifecycleinitiative.org/module-2-scp-hotspots/)
[132] SCP-HAT (http://scp-hat.lifecycleinitiative.org/module-2-scp-hotspots/)

Water footprint of construction sector

Water use footprint in the construction sector is defined as the water use in construction of all buildings, roads and railways, utilities and other civil engineering activities based on consumption footprint[133]. The water use footprint in the construction sector of Indonesia was increased with the rate of 0.008 billion cubic meters per year from 2010 to 2018. In 2018, the total water use footprint in Indonesia was 0.32 billion cubic meters per year. The increase in economic activities and population growth of the country might be the reasons for overall increase in water use footprint in the construction sector of Indonesia. The time series of water use footprint in the construction sector of Indonesia from 2010 to 2018 is shown in **Figure 3-70**.

Water footprint of tourism sector

Water use footprint in tourism sector is defined as the water use in hotels and restaurants for accommodation and food service activities[134]. The water use footprint in the tourism sector of Indonesia was decreased from 2010 to 2018. In 2018, the total water use footprint in Indonesia was 0.42 billion cubic meters per year. From 2013 to 2015, it decreased sharply onwards it recovered. The application of better water management policies or using the more efficient use of water in the tourism sector could be the reason of this change. Overall, it was decreased with the rate of 0.005 billion cubic meters per year from 2010 to 2018. However, the tourism sector of Indonesia was improved in terms of revenue[135], which is evidence of decoupling. The time series of water use footprint in the tourism sector of Indonesia from 2010 to 2018 is shown in **Figure 3-70**.

Water footprint of transport sector

Water use footprint in the transport sector is defined as the water use in land transport, water transport, air transport, transport via pipeline, warehousing and support activities for transportation based on consumption footprint. The water use footprint in the transport sector of Indonesia was slightly increased with the rate of 0.0004 billion cubic meters per year

[133] SCP-HAT (http://scp-hat.lifecycleinitiative.org/module-2-scp-hotspots/)
[134] SCP-HAT (http://scp-hat.lifecycleinitiative.org/module-2-scp-hotspots/)
[135] CEIC, 2021. https://www.ceicdata.com/en/indicator/indonesia/tourism-revenue-growth Accessed 27 December 2021

from 2010 to 2018. In 2018, the total water use footprint in Indonesia was 0.04 billion cubic meters per year. The overall increase in water use footprint of the transport sector of Indonesia is not significant as the drivers such as population, economy etc. increased significantly. The time series of water use footprint in the transport sector of Indonesia from 2010 to 2018 is shown in **Figure 3-70**.

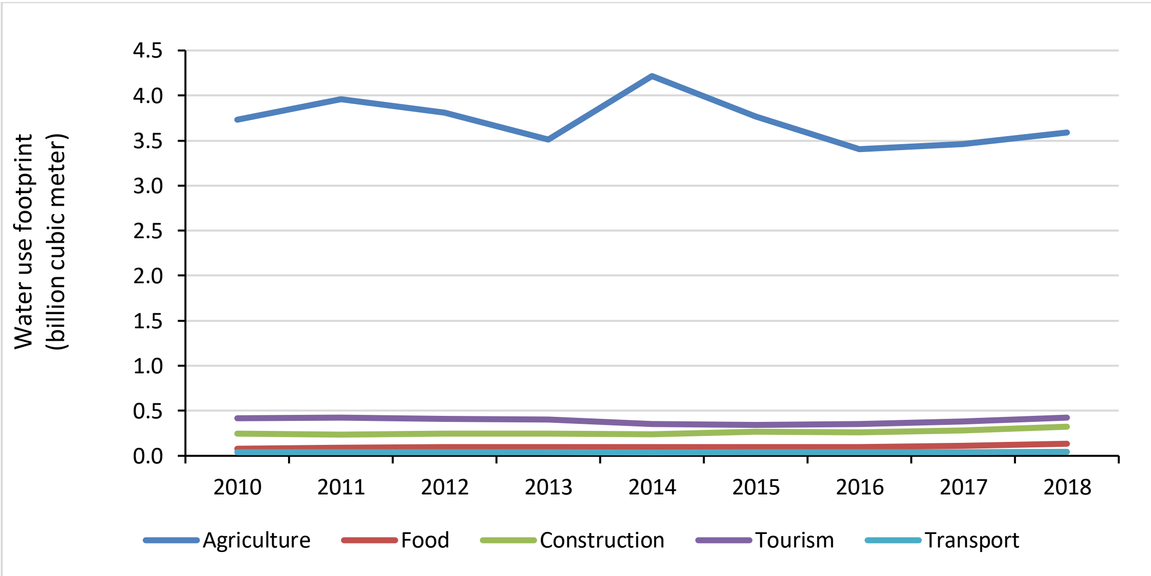

Figure 3-70 Water use footprint of five different sectors of Indonesia

3.3.1.2 Land use

<u>Total land use</u>

The total land use of Indonesia decreased slightly from 1992 to 2015. In 1992, the total land use of Indonesia was 177.19 million hectares. Overall, it was decreased with the rate of 0.003 million hectare annually from 1992 to 2015. The slight decrease in total land use of Indonesia is due to the rapid deforestation. In terms of percentage, total land use of Indonesia increased by almost 0.02 percent from 1992 to 2015. However, in the same time forest land cover and agricultural land use increased slightly. The population, industrial activities, and food security challenges are among the few reasons of rapid urbanization, deforestation, and agricultural land expansion. The time series of total land use of India from 1992 to 2015 is shown in **Figure 3-71**.

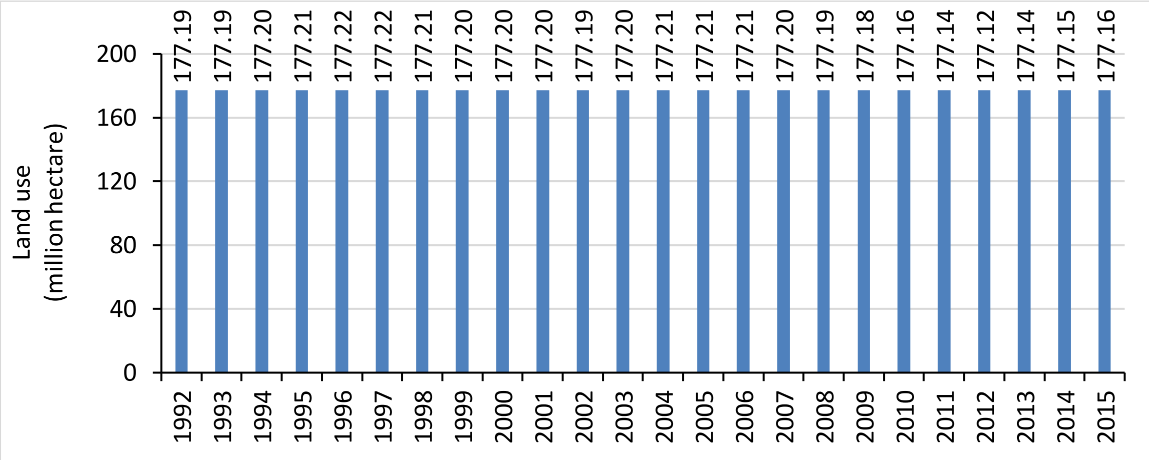

Figure 3-71 Total land use of Indonesia

<u>Total land use per capita</u>

The total land use per capita of Indonesia decreased significantly from 1992 to 2015. In 1992, the total land use per capita of Indonesia was 0.94 square meter per capita annually, which has decreased by 28 percent until 2015. Overall, it was decreased with the rate of 0.011 square meter per capita from 1992 to 2015. In terms of percentage, the total land use per capita of Indonesia decreased by almost 27 percent from 1992 to 2015. This significant decrease is probably due to rapid population growth while the land resources are the same as it was in 1992. The time series of total land use per capita of Indonesia from 1992 to 2015 is shown in **Figure 3-72**.

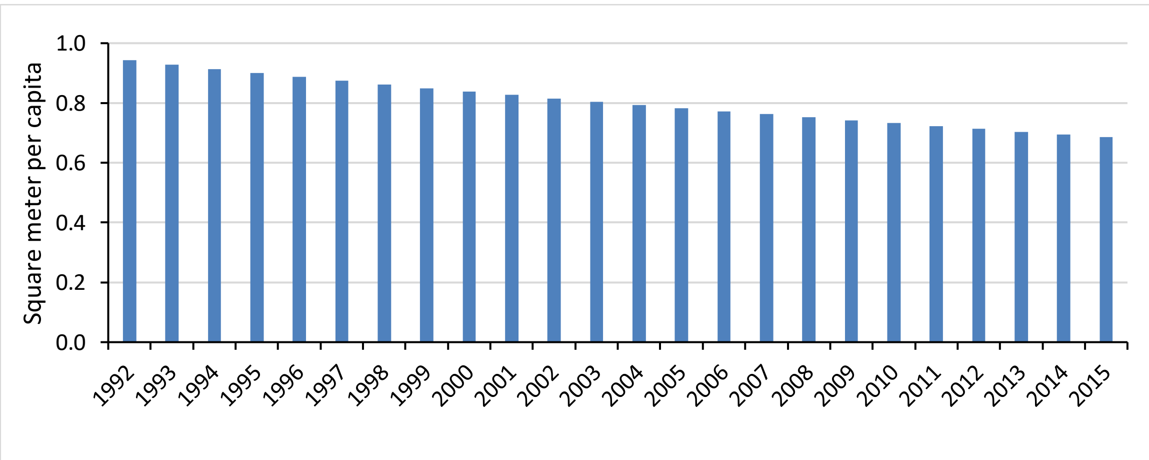

Figure 3-72 Total land use per capita of Indonesia

Total land use intensity

The total land use intensity of Indonesia decreased significantly from 1992 to 2015. In 1992, the total land use intensity of Indonesia was 13.84 square meter per dollar annually, which has decreased by almost seven folds until 2015. Overall, it decreased at the rate of 0.54 square meter per dollar from 1992 to 2015. In terms of percentage, total land use intensity of Indonesia decreased by almost 85 percent from 1992 to 2015. The significant decrease in the total land use intensity of Indonesia is probably due to the rapid industrialization and robust urbanization as a result massive increase in GDP. The time series of total land use intensity of Indonesia from 1992 to 2015 is shown in **Figure 3-73**.

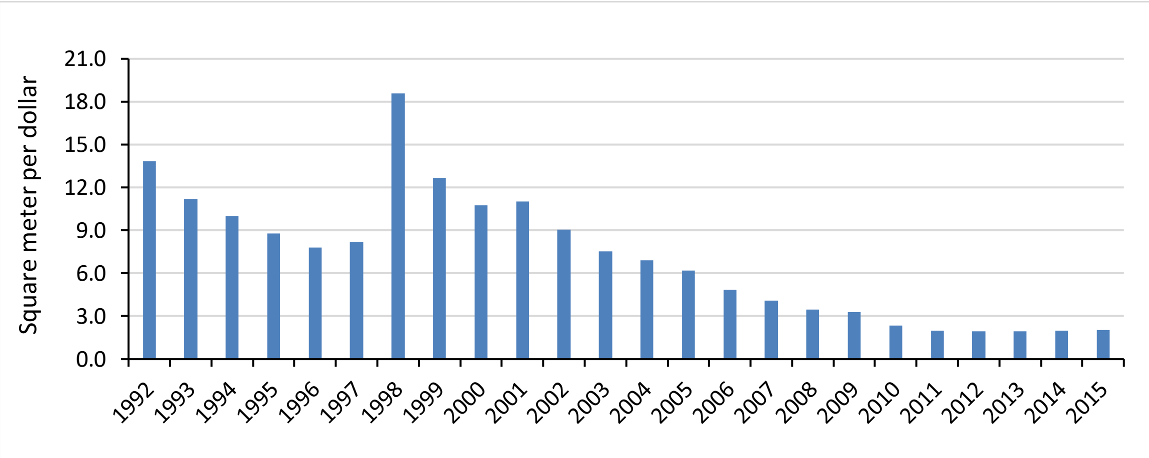

Figure 3-73 Total land use intensity of Indonesia

Land footprint in major sectors

Land footprint in agriculture sector

Land use footprint in agriculture sector deals with the land used for the cultivation of food crops (wheat, maize, cereals etc.), oil, fiber, non-perennial, spices, aromatic, drug and pharmaceutical, crops beverage crops perennial crops, plant propagation, and land use in livestock farming based on consumption footprint [136]. Land use footprint of the agriculture sector in Indonesia showed an increasing trend from 1990 to 2018. In 1990, the land use of the agriculture sector in Indonesia was 13.5 million hectares that increased by 15.7 million

[136] SCP-HAT (http://scp-hat.lifecycleinitiative.org/module-2-scp-hotspots/)

hectares by the end of 2018. The highest land use footprint of the agriculture sector was noticed in 2018 at 29.19 million hectares. Overall, it was increased at the rate of 0.66 million hectares per year from 1990 to 2018. The increase in land use footprint of the agriculture sector is possibly be due to the increase in economic development and population expansion. The time series of land use footprint of the agriculture sector of Indonesia from 1990 to 2018 is shown in **Figure 3-74**.

Land footprint in food sector

Land use footprint of the food sector deals with the land use by processing, preserving, and manufacture of meat and fish-based products, cereal-based products, food crop product, mixed food and feed, cocoa, fiber-based products, chocolate and sugar confectionery, vegetable and animal oils and fats, and manufacture of dairy products, alcoholic and other beverages, tobacco products based on consumption footprint[137]. Land use footprint of the food sector of Indonesia showed a slightly increasing trend from 1990 to 2018. In 1990, the land use of food sector in Indonesia was 13.72 million hectares that increased by 9 million hectares by the end of 2018. The highest land use footprint of the food sector was noticed in 1996 that was 26.34 million hectares. Overall, it was increasing with the rate of 0.266 million hectares per year from 1990 to 2018. The increase in land use footprint of food sector is probably be due to the increase in economic development and population expansion. The time series of land use footprint of the food sector of Indonesia from 1990 to 2018 is shown in **Figure 3-74**.

Land footprint in construction sector

Land use footprint in construction sector is defined as the land use in construction of all buildings, roads and railways, utilities and other civil engineering activities based on consumption footprint[138]. Land use in the construction sector of Indonesia showed a fluctuating trend from 1990 to 2018. In 1990, the land use footprint of the construction sector in Indonesia was 3.65 million hectares that increased by 0.77 million hectares by the end of 2018. The highest land use in the construction sector was noticed in 2010 at 4.88 million

[137] SCP-HAT (http://scp-hat.lifecycleinitiative.org/module-2-scp-hotspots/)
[138] SCP-HAT (http://scp-hat.lifecycleinitiative.org/module-2-scp-hotspots/)

hectares. Overall, it was increasing with the rate of 0.0457 million hectares per year from 1990 to 2018. The increase in land use footprint of the construction sector is probably due to the rapid increase in population. The time series of land use footprint of the construction sector of Indonesia from 1990 to 2018 is shown in **Figure 3-74**.

Land footprint in tourism sector

Land use footprint of tourism sector is defined as the land use in hotels and restaurants for accommodation and food service activities based on consumption footprint[139]. Land use footprint of the tourism sector in Indonesia almost doubled, increased by 1.95 million hectares from 1990 to 2018. Overall, it decreased with the rate of 0.0708 million hectares during 1990 to 2018. The increase in land use footprint of the tourism sector in Indonesia possibly due to the expansion in the tourism sector. The drawdown in the land use footprint of the tourism sector in 1998 is probably due to the economic decline in the Indonesian GDP in the same year. The time series of land use footprint of the tourism sector of Indonesia land from 1990 to 2018 is shown in **Figure 3-74**.

Land footprint in transport sector

Land use footprint of the transport sector is defined as the land use in land transport, water transport, air transport, transport via pipeline, warehousing and support activities for transportation based on consumption footprint. Land use footprint of the transport sector in Indonesia increased significantly especially in the earlier part of the first decade of this century. In 1990, the land use footprint of the transport sector in Indonesia was 0.16 million hectares that was decreased by 0.16 million hectares by the end of 2018. The highest land use footprint of the transport sector was noticed in 2002 i.e., 0.39 million hectares. Overall, it increased at the rate of 0.0053 million hectares per year from 1990 to 2018. The increase in land use in the transport sector is probably due to the increase in economic development and population expansion. The time series of land use footprint of the transport sector of Indonesia from 1990 to 2018 is shown in **Figure 3-74**.

[139] SCP-HAT (http://scp-hat.lifecycleinitiative.org/module-2-scp-hotspots/)

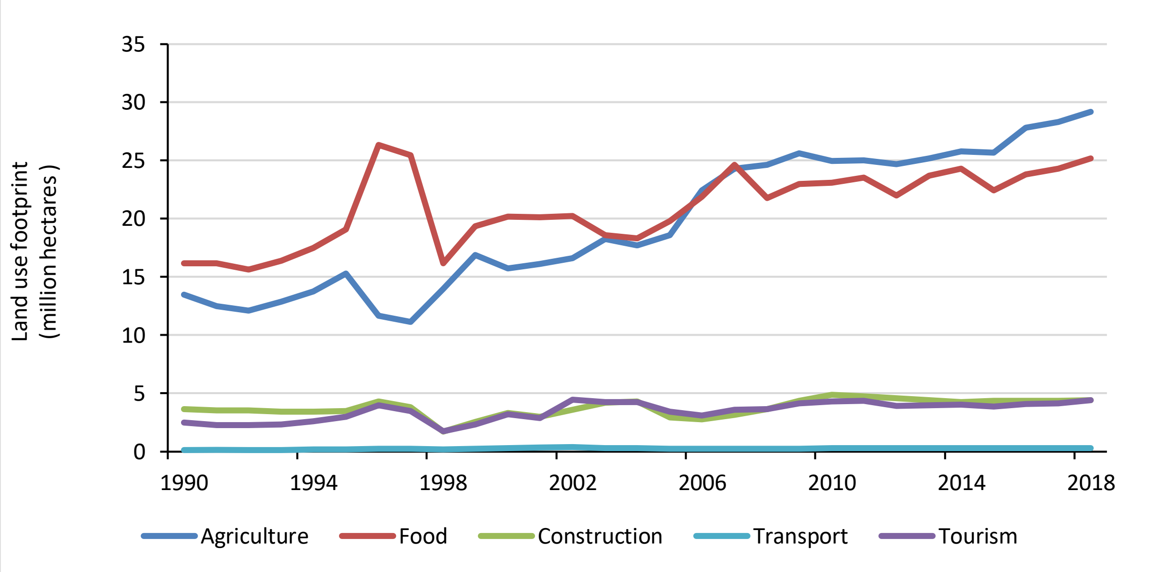

Figure 3-74 Land use footprint of five different sectors of Indonesia

3.3.1.3 Material use

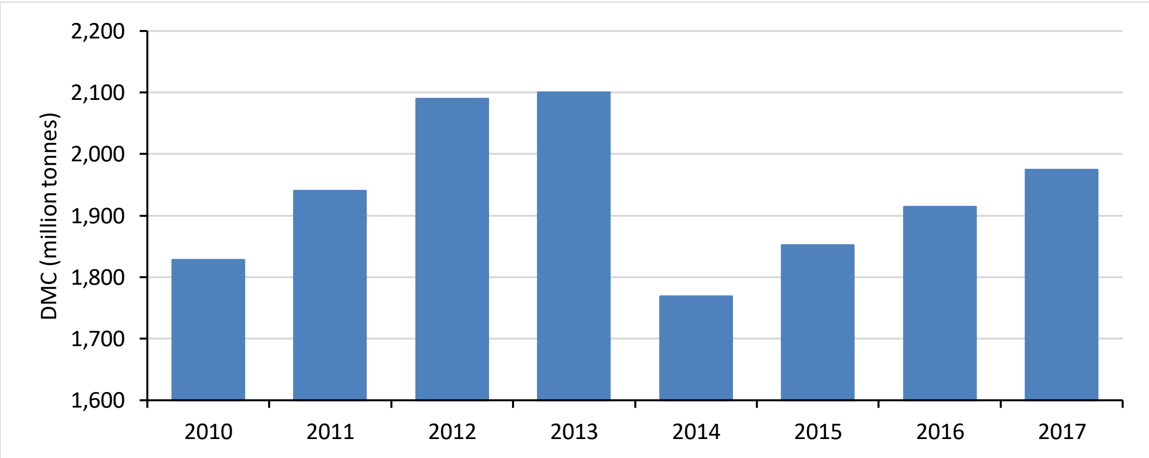

Figure 3-75 Domestic material consumption in Indonesia (2010 – 2017)

As presented in **Figure 3-75**, the total DMC in the Indonesia has increased from a little above 1.8 billion tonnes in 2010 to around 2.0 billion tonnes in 2017. During the concerned duration (2010-2017), the DMC in the country increased from 1.8 billion in 2010 tonnes and reached to 2.1 billion tonnes in 2013 which was the highest. After that there was a sharp decrease of more than 15% in the country's DMC in 2014 which was due to the political instability in the country. However, after Joko Widodo succeeded Susilo Bambang Yudhoyono (SBY), the government took measures to ease regulations to stimulate the economy.[140] The country's DMC again showed increasing trend from the lowest in 2014 and reached to a little below 2 billion tonnes in 2017 which is still lower as compared to 2013. However, the country stands at number three (following only China and India) when it comes to overall DMC in the Asian region. This gigantic amount of material consumption is due to the large population size which makes Indonesia the most populous country in the Southeast Asia.[141] The country's population increased to around 264 million in 2017 from 241 million in 2010.

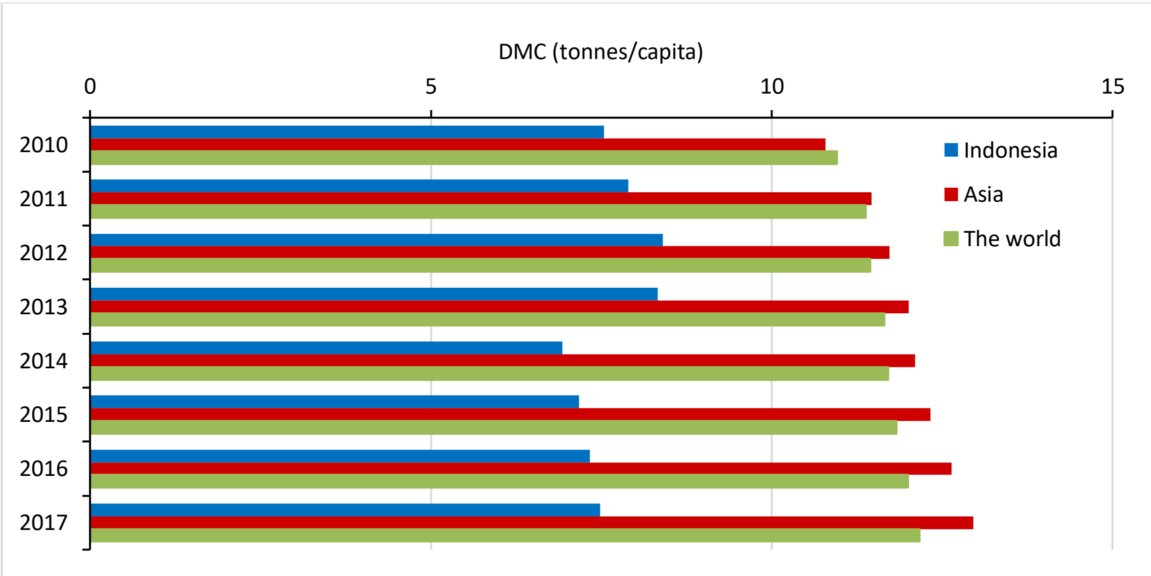

Figure 3-76 Per capita domestic material consumption in Indonesia, Asia, and the World (2010-2017)

Figure 3-76 shows the per capita DMC of Indonesia, Asia, and the World from 2010 to 2017. In 2010, the country's per capita DMC was 7.54 tonnes per capita which was slightly decreased with a rate of less than 1% and reached to 7.48 tonnes per capita in 2017. Moreover, the country's per capita DMC is almost one and a half times lower as compared to the per capita DMC in Asia and the World. From **Figure 3-75** and **Figure 3-76**, it can be seen that the country's per capita and overall DMC almost followed the same trend throughout the concerned time period. However, the slight decrease in DMC per capita is due to the increasing population as well as the decreased economic activities. The country experienced

[140] https://en.wikipedia.org/wiki/Economy_of_Indonesia#cite_note-61
[141] https://www.oecd.org/indonesia/Active-with-Indonesia.pdf

rapid growth since the end of the Asian Financial Crisis in 1998, up until 2014, GDP growth averaged over 5% per annum. However, recently slowing growth rates indicated that many underlying policy challenges still need to be tackled to ensure sustainable and inclusive growth. [142]

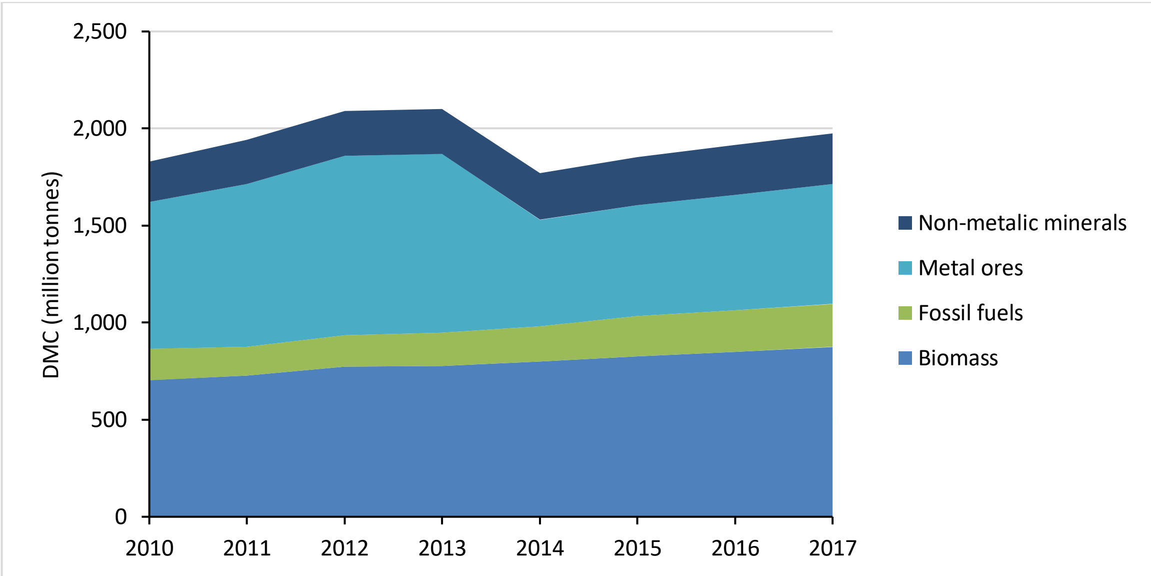

Figure 3-77 Domestic material consumption by material category in Indonesia (2010 – 2017)

Figure 3-77 presents the category-wise DMC in Indonesia. It can be seen that different material categories show different growth trajectories. From 2010 to 2017, DMC of biomass, fossil fuels, and non-metal minerals has increased at a rate of 0.027%, 0.039%, and 0.029%, respectively, while the DMC of metal ores decreased at a rate of 0.025%. It can be observed that the percentage growth in fossil fuels' consumption is highest among all four material categories, followed by non-metallic minerals. However, in the absolute terms the share of biomass is the largest in the country's overall DMC with a total of around 0.87 billion tonnes followed by metal ores, non-metallic minerals, and fossil fuels with a total of 0.62, 0.26, and 0.21 billion tonnes, respectively. The overall total annual DMC of biomass, fossil fuels, metal ores, and non-metallic minerals has increased with a rate 24%, 36%, -18% and, 26% in 2017 from 2010. These statistics indicate that the Indonesia's economy is moving rapidly towards economic development, urbanization and increased global demand for domestic

[142] https://www.oecd.org/indonesia/Active-with-Indonesia.pdf

commodities. Owing to the above- mentioned reasons, the country is facing serious environmental challenges related to air and water pollution, waste management, climate change, biodiversity loss and depletion of natural resources.

Material use by major sectors

Natural capital constitutes about one quarter of Indonesia's total wealth, but this capital is being rapidly depleted while not being offset by commensurate investments in human or produced capital. In the period from 1970 to 2017, domestic extraction in Indonesia increased almost six-fold, from 428.2 million tonnes in 1970 to 2.4 billion tonnes in 2017. Hence, despite Indonesia's increasing industrialization, its economy still heavily relies on material extraction. As a tropical archipelago with a significant dependence on agriculture and natural resources, Indonesia is highly vulnerable to the effects of climate change. The economic consequences of climate change represent the highest potential cost to Indonesia's economy in the long term, amounting to between 2.5% to 7% of GDP by the end of the century. [143] **Figure 3-78** presents the material use in six major sectors in Indonesia.

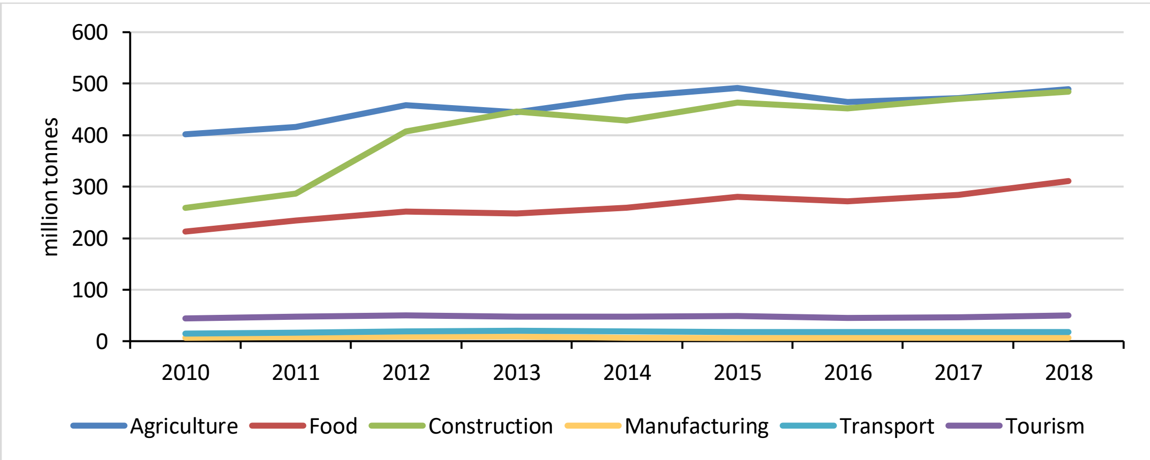

Figure 3-78 Sector-wise material footprint in Indonesia (2010-2018)

It can be seen from **Figure 3-78** that the agriculture sector has the highest material consumption during the considered time series. The overall material consumption by agriculture sector has increased by more than 22% and reached to 490 million tonnes in 2018

[143] https://documents1.worldbank.org/curated/en/699081468040545730/pdf/507620v20Revis1ox0info10CEA1english.pdf

from 402 million tonnes in 2010. On the other hand, the construction sector is the second largest sector in the country regarding material consumption with the highest percentage growth in material consumption among all the six concerned sectors. The material consumption of construction sector was around 259 million tonnes in 2010 that has increased to more than 484 million tonnes in 2018. The third largest sector regarding material consumption is the food sector with a percentage growth of around 46% that was higher as compared to the percentage growth in agriculture sector during 2010 to 2018. The sectors including tourism, transport, and manufacturing are the bottom three sectors, respectively.

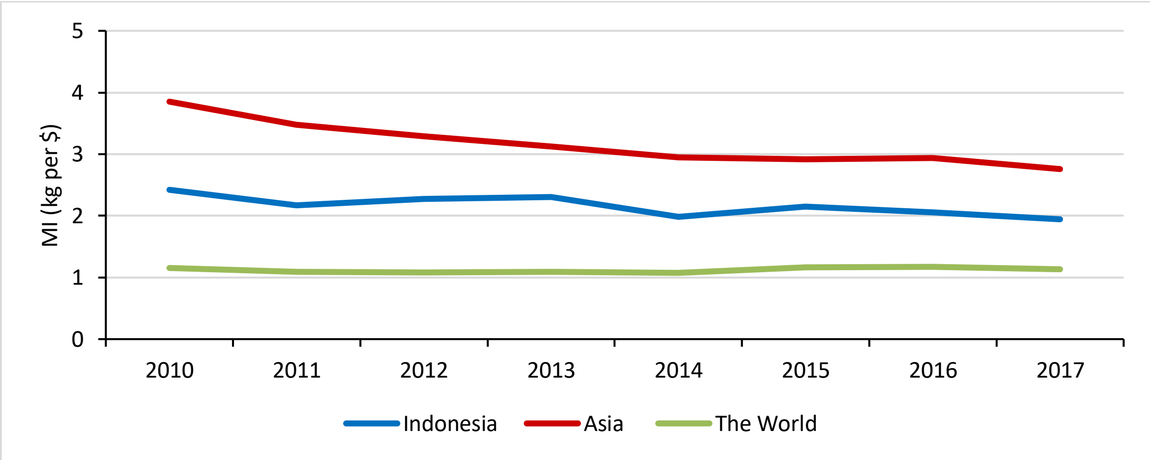

Figure 3-79 Material intensity for Indonesia, Asia, and the World (2010 – 2017)

Figure 3-79 presents the comparison of material intensity (kg per $) between Indonesia, Asia, and the world. The material intensity of the world remained almost constant during 2010-2017. The material intensity in Indonesia remained lower as compared to overall region throughout the concerned duration. However, there was a tremendous improvement in the material intensity of overall Asian region so also for Indonesia. A decrease of 24% was observed in the material intensity of the country, while overall regional material intensity was decreased around 29% during 2010 to 2017. On the other hand, in 2017, the material intensity of Indonesia was still 1.7 times higher than the world average. The statistics show that the country has performed remarkably to improve the efficiency of its production and consumption system while upholding its rank as the leading economy in the Southeast Asia, world's 10th largest economy in terms of purchasing power parity (PPP), and a member of the

Group of 20 (G-20).[144] However, the country still has to go a long way to attain the material intensity on par with the industrialized world. To do so, adoption of innovative urban development, advanced modes of transportation, efficient energy production, and modern economic structure is required.

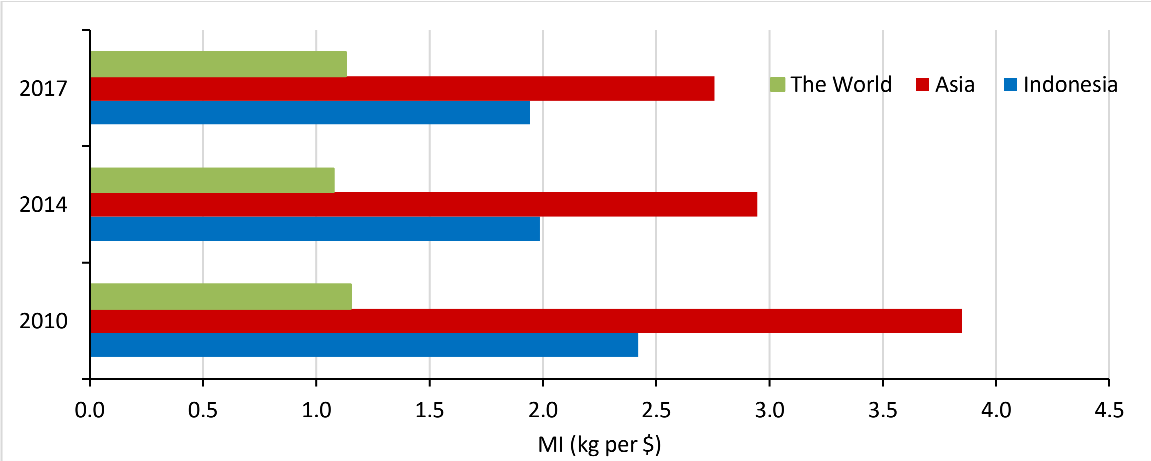

Figure 3-80 Material intensity of Indonesia, Asia, and the World (2010, 2014, 2017)

Figure 3-80 compares the material intensity of Indonesia with the material intensity of Asia as well as the whole world for the years 2010, 2014 and 2017. It can be seen that material intensity of Indonesia and overall Asian region remained higher when compared to overall World's material intensity during all three concerned years. On the other hand, when compared with overall region, the material intensity of Indonesia remained lower in 2010, 2014, and 2017. The reason behind country's commendable performance is rooted in its economic planning that follows a 20-year development plan, spanning from 2005 to 2025. It was segmented into 5-year medium-term development plans called the RPJMN (Rencana Pembangunan Jangka Menengah Nasional), each with different development priorities. The current medium-term development plan is the last phase of the long-term plan. It aims to further strengthen Indonesia's economy by improving the country's human capital and competitiveness in the global market.[145] Compared to its regional peers, Indonesia is a bright spark in terms of placing emphasis on a circular transition. Having elaborated on circular economy concepts in Vision Indonesia 2045, the largest economy in Southeast Asia is pushing

[144] https://www.worldbank.org/en/country/indonesia/overview#1
[145] https://www.worldbank.org/en/country/indonesia/overview#1

ahead with plans to develop a National Circular Economy Roadmap, which would be guided by the next National Medium Term Development Plan 2025–2029.[146]

Material footprint of consumption

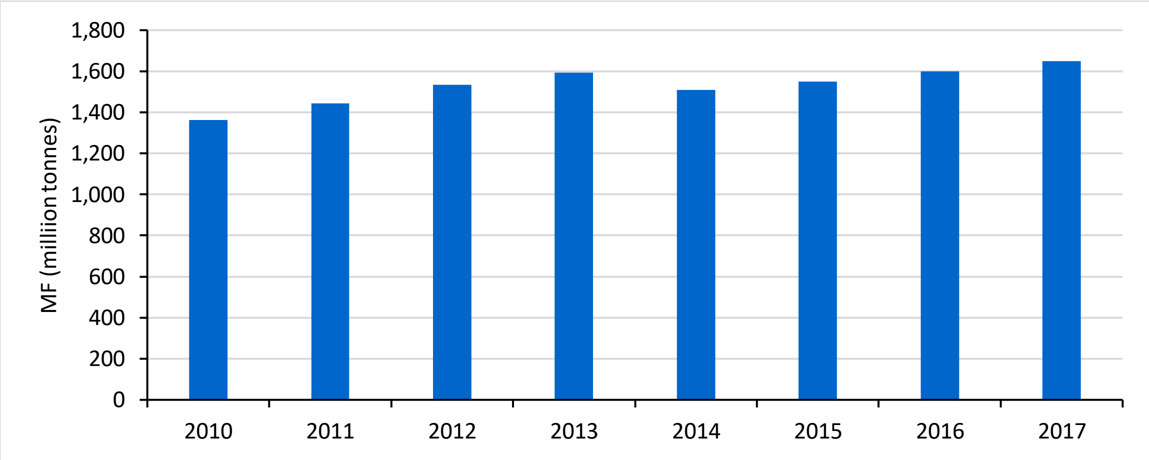

Figure 3-81 Material footprint of consumption in Indonesia (2010 – 2017)

Figure 3-81 presents the material footprint of consumption of Indonesia. It can be seen that the material footprint of consumption has continuously increased in Indonesia from 1.4 billion tonnes in 2010 to 1.6 billion tonnes in 2013, after that a slight decrease was experienced in 2014. In 2014 the total material footprint of Indonesia was around 1.5 billion tonnes that was increased with a rate of 9% and reached to a total of around 1.7 billion tonnes in 2017. From 2010 to 2017, the overall increase in Indonesia's material footprint was around 21%.

[146] https://development.asia/explainer/how-indonesia-can-transition-circular-economy-through-5-key-sectors

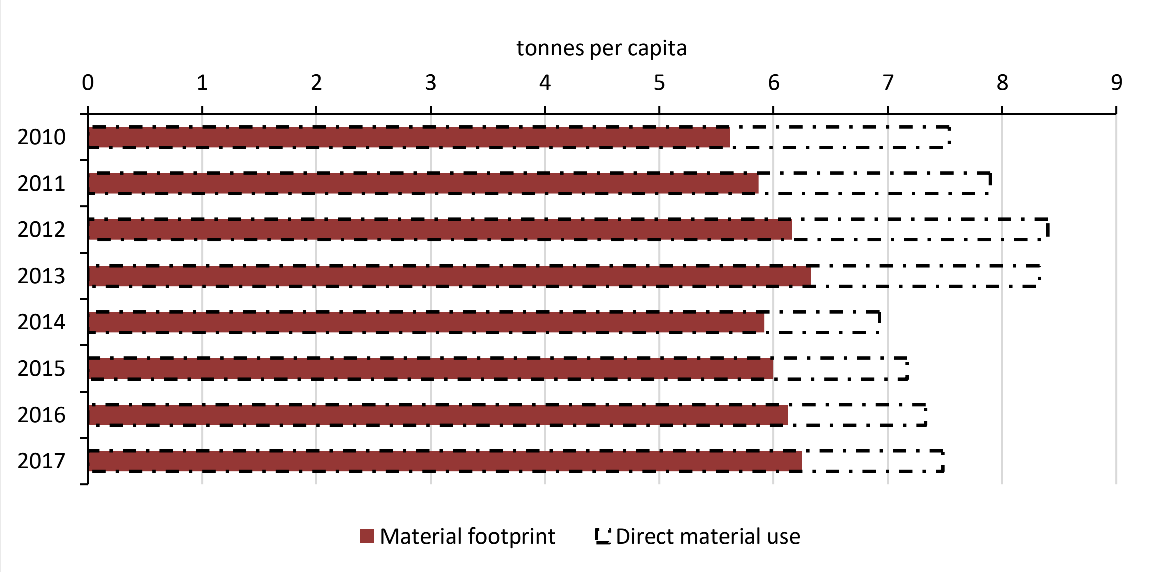

Figure 3-82 Material footprint per capita compared to domestic material consumption per capita in Indonesia (2010-2017)

Figure 3-82 compares the material footprint per capita with the DMC per capita of the Indonesia from 2010 to 2017. It can be seen from **Figure 3-82** that Indonesia has higher DMC per capita as compared to material footprint per capita from 2010 to 2017. This is because the country is an agriculture-based economy and earns most of its foreign exchange by the export of primary agricultural products to Australia which accounts for around 40% of all merchandise exports. Moreover, Indonesia is a growing market for exports of goods and services, with promising prospects looking forward.[147] In 2019, Indonesia exported a total of $US 186 billion, making it the number 30 exporter in the world.[148]

3.3.1.4 Energy use

Indonesia is one of the fastest growing countries in the world not only in terms of economy, but also in terms of energy consumption. Robust economic growth, increasing population and abrupt urbanization are a few of the key drivers for this intensive increase in energy demand. Indonesia is the top energy consumer in the Association of Southeast Asian Nations (ASEAN); almost accounting for forty percent of total energy consumption among the region

[147] https://asialinkbusiness.com.au/indonesia/getting-started-in-indonesia/indonesias-exports?doNothing=1

[148] https://oec.world/en/profile/country/idn#:~:text=In%202019%2C%20Indonesia%20exported%20a,30%20exporter%20in%20the%20world.&text=The%20most%20common%20destination%20for,and%20India%20(%2413.6B).

members.[149] The energy consumption is concentrated in the three sectors, viz., residential, industrial and transport as shown in **Figure 3-83**. However, there was a sharp decline (i.e., 53% in 1990 to 20% 2019) in the energy use of residential sector. On the other hand, industrial and transportation sectors have shown a significant increase during past three decades. However, agriculture/forestry and services sectors did not fluctuate very much between 1990 to 2019.

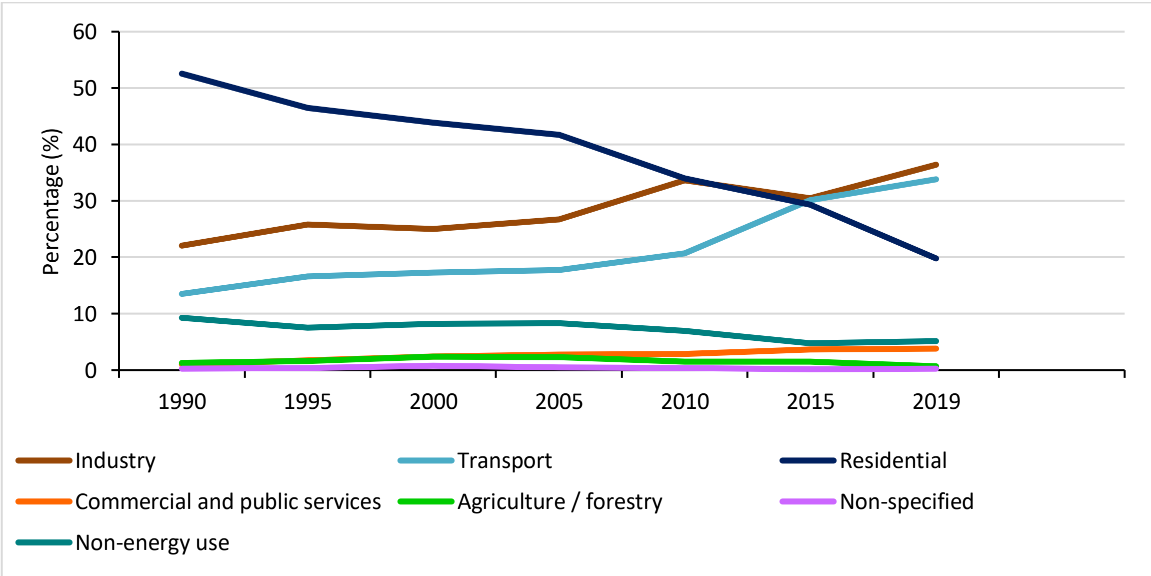

Figure 3-83 Sectoral share in total final energy consumption in Indonesia (1990-2019) [150]

[149] IRENA. (2017). EXECUTIVE SUMMARY. *Renewable energy prospects: Indonesia*. Available at: https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2017/Mar/IRENA_REmap_Indonesia_summary_2017.pdf?la=en&hash=F530E18BAFC979C8F1A0254AFA77C9EBC9A0EC44

[150] IEA. (2022). International Energy Agency. Retrieved from https://www.iea.org/data-and-statistics/data-browser?country=WORLD&fuel=Energy%20consumption&indicator=TFCShareBySector

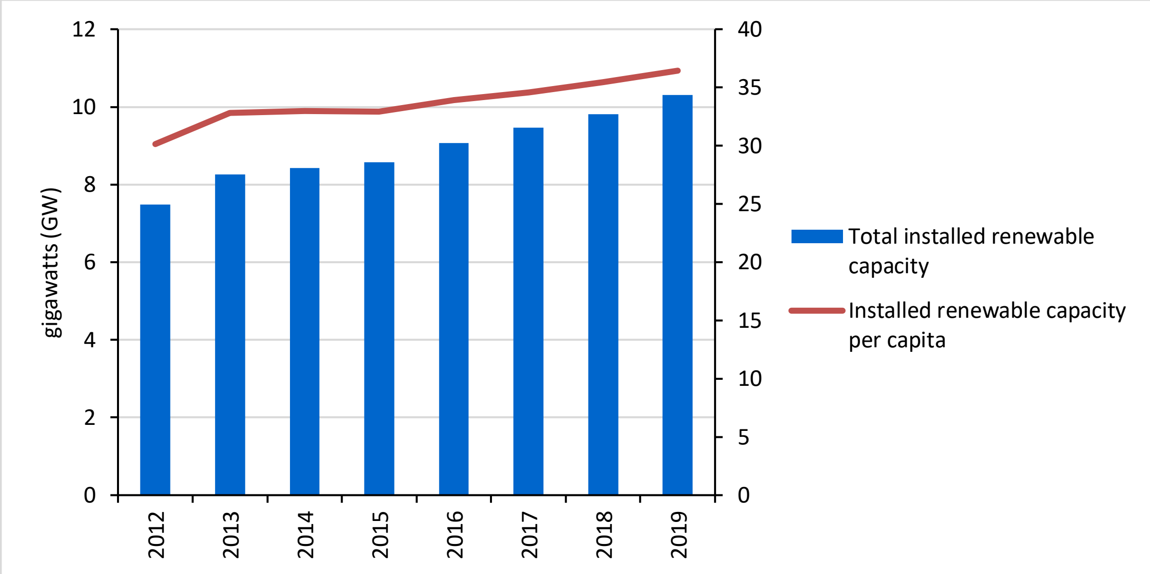

Figure 3-84 Installed renewable electricity-generating capacity in Indonesia (2012-2019)[151,152]

The installed renewable electricity generation capacity has been increased from 7.4 to 10.3 gigawatts during 2012 to 2019 as shown in **Figure 3-84**. Indonesia already has ambitious targets to increase the share of renewable energy in energy mix and adopted a mixed-energy approach in the energy industry. The adaptation of clean energy sources has also been declared a national policy mandate in Indonesia. Government Regulation No. 79/2014 on National Energy Policy outlined the goal of transforming the primary energy supply mix by 2025 and 2050, with new and renewable energy accounting for at least 23% in 2025 and at least 31% in 2050.[153] Furthermore, when the environmental costs are included in while considering the impacts on climate change and air pollution, Indonesia could save around USD 15.6 billion and USD 51.7 billion per year by scaling up the renewables. [154]

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151 UNEP. (2022). The United Nations Environment Programme. Available at: https://wesr.unep.org/downloader

152 IRENA (2022).RENEWABLE CAPACITY STATISTICS 2022. *The International Renewable Energy Agency (IRENA)*. Available at: https://www.irena.org/IRENADocuments/Statistical_Profiles/Asia/China_Asia_RE_SP.pdf. [Accessed on April 2022]

153 UNFCCC. (2021). Updated Nationally Determined Contributions by Republic of Indonesia. Available at: https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Indonesia%20First/Updated%20NDC%20Indonesia%202021%20-%20corrected%20version.pdf

154 IRENA. (2017). EXECUTIVE SUMMARY. *Renewable energy prospects: Indonesia*. Available at: https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2017/Mar/IRENA_REmap_Indonesia_summary_2017.pdf?la=en&hash=F530E18BAFC979C8F1A0254AFA77C9EBC9A0EC44

Energy Intensity

Energy is vital to Indonesia's economy, and its sustainable development is critical to the country's progress. Indonesia has been blessed with a wealth of commodities and resources. The rapid urbanization and industrialization are the key drivers of the risen energy demand of the country. Improving energy efficiency is the fastest and least costly instrument to fulfil the energy needs. Energy efficiency refers to reducing energy consumption while maintaining the same level of service; it just not improves economic competitiveness via demand-side management, minimum performance requirements, and efficient technologies but also have the significant impacts on the environment.

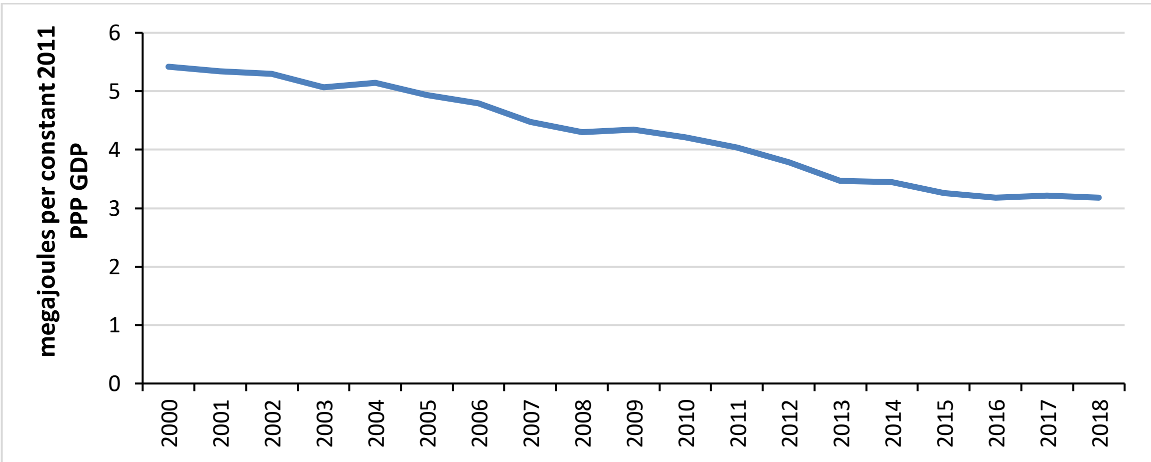

Figure 3-85 Energy intensity of Indonesia (200-2018)

Indonesia has also made significant improvement to enhance the efficiency during the last two decades. The energy intensity has been reduced from 5.4 to 3.2 megajoules per constant 2011 PPP GDP during 2000 to 2018 as shown in **Figure 3-85**. The National Energy General Plan (also referred as RUEN) targets to lower primary energy intensity by 1% every year during 2015 to 2025, along with final energy consumption by 17 percent and 39 percent, respectively, by 2025 and 2050.[155] On the other hand, Indonesia's current regulations are expected to result in a 2% decrease in energy usage by 2025, however, the country has an

[155] National Energy General Plan (RUEN). (2022). Ministry of Energy and Mineral Resources. Available at: https://policy.asiapacificenergy.org/node/4173

even bigger potential for energy efficiency savings of 10% to 35% throughout the household, municipal, industrial, and transportation sectors.[156]

3.3.1.5 Agricultural productivity

Indonesia, the fifth most populated country in the world, is a major producer of agricultural products. The country is also a well-known exporter of agricultural products. The Islands of Java and Bali account for only 7 percent of Indonesia's total land area but 60 percent of the population.[157] Agriculture is very intensive on these islands, with up to three crop rotations per year.[157] However, given the limited and competing use of resources, raising agricultural productivity is of paramount importance. To date, most of the existing work on Indonesia's agricultural sector is at the national level. Raising agricultural productivity is thus important for maintaining food security and mitigating the danger of rising food prices while at the same time improving the living standards of Indonesia's poor people.

The productivity of food crops is highly affected by the cultivation profiles implemented by the farmers, such as type of soil, planting technique, production facility, and infrastructure utilization, as well as other factors, including government assistance, and climate change impacts.

Indonesia maintains several domestic programs that are classified as domestic supports. These include programs to promote agricultural development, stockholding and administered price systems for some commodities, and domestic food aid. In addition, the Government provides subsidized credits to farmers and, until recently, subsidized the use of fertilizers and pesticides. These governmental intervention programs generally had a favorable effect on the crop yield (agricultural productivity) as shown in **Figure 3-86**.

[156]Asian Development Bank (ADB). (2020). Indonesia energy sector assessment, strategy, and road map update. Available at: https://www.adb.org/sites/default/files/institutional-document/666741/indonesia-energy-asr-update.pdf
[157] Krishnamurti, Indra, & Muhammad D. Biru. (2019). Expanding Hybrid Rice Production in Indonesia. Center for Indonesian Policy Studies, DOI: 10.35497/287925.

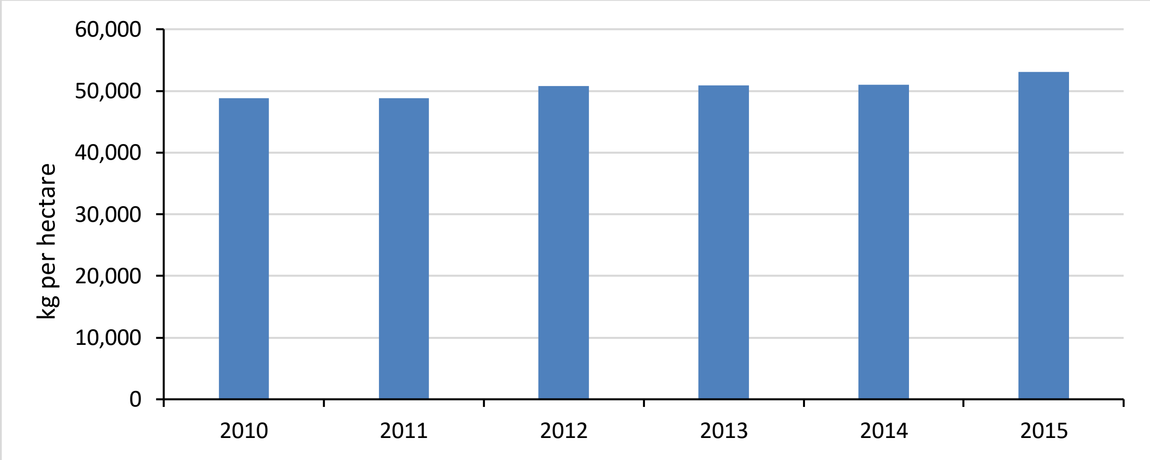

Figure 3-86 Agricultural productivity in Indonesia (2010 - 2015)

3.3.1.6 Greenhouse gas emissions

Indonesia is the world's fourth most populous country after China, India, and the United States. While Indonesia's economy has grown steadily over the past 10 years at 5 - 6 percent annually.[158] For these reasons, in the last decade, GHG emissions have increased in almost all sectors; the overall GHG emissions have generally increased as shown in **Figure 3-87**.

In 2015, Indonesia joined a global wave of countries that submitted their post-2020 climate pledges to the United Nations Framework Convention on Climate Change (UNFCCC), known as intended nationally determined contributions (INDCs). Since then, it has signed and ratified the Paris Agreement, and later formally submitted its first nationally determined contribution (NDC) in 2016, reiterating its commitment to a low-carbon, climate-resilient future. The achievement of Indonesia's mitigation targets—along with those of over 190 other countries—will determine whether the increase in global average temperature will be held below 2° Celsius and limited even further to 1.5° Celsius above preindustrial levels, as proposed in the Paris Agreement.

[158] World Bank. 2016. Indonesia Data (Database). https://data.worldbank.org/country/ID

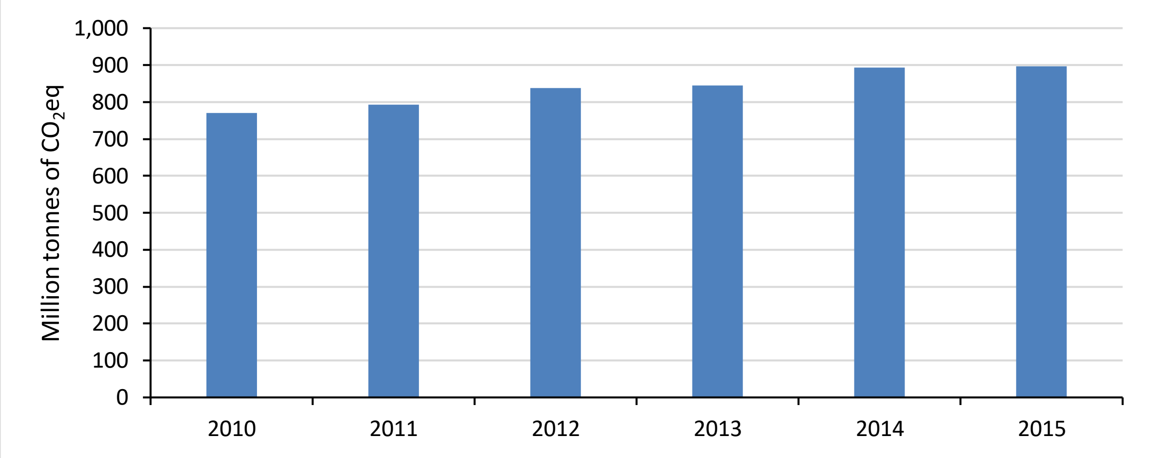

Figure 3-87 Total GHG emissions Indonesia (2010 - 2015)

Greenhouse gas intensity (2010 - 2015)

The GHG intensity of the country's economy quantifies how much emissions are generated for each unit of GDP. **Figure 3-88** shows that the intensity is generally decreasing. Indonesia has targets to improve energy efficiency. Its National Master Plan for Energy Conservation sets a goal of decreasing energy intensity by 1% annually until 2025.[159]

The Indonesian government has not yet fully implemented its commitment to reduce emissions from coal. To meet the carbon-neutral goal by 2060, the government has announced that they would not build a new coal-fired power plant after 2023. However, at the same time, around 2 GW of coal capacity has started operating. Moreover, in the NDC, Indonesia promised to reduce coal by 30% by 2025 and 25% by 2050.[159]

[159] Dunne, D. (2019, April 23). *The Carbon Brief Profile: Indonesia*. Carbon Brief. https://www.carbonbrief.org/the-carbon-brief-profile-indonesia

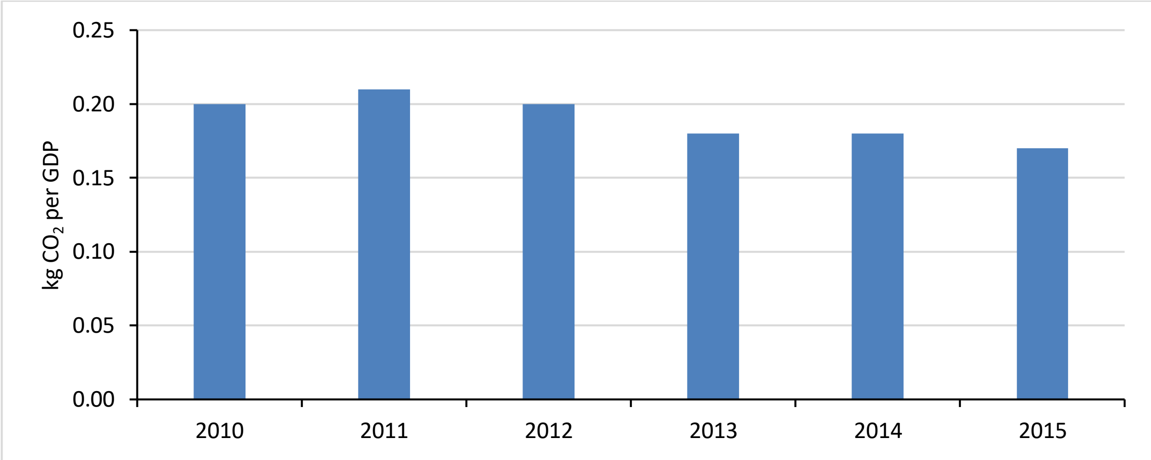

Figure 3-88 Indonesia's GHG emissions intensity (2010 - 2015)

Greenhouse gas from major sectors

Greenhouse gas from energy use

The energy sector is very important as it provides the energy needed to support daily activity and fuel economic activity. This sector also generates government revenues from sales of natural resources to domestic and export markets royalties and various taxes. Energy is consumed in transport, industrial, agricultural, and building sectors. Indonesia has the 16th biggest economy and the largest in Southeast Asia. Its emissions stem from deforestation and peatland mega-fires and, to a lesser extent, the burning of fossil fuels for energy. The largest driver of overall GHG is emissions from fuel combustion. In Indonesia, emissions have increased significantly since 1990, reaching a high of about 360 MtCO_2 in 2015 (as shown in **Figure 3-89**) and 581 MtCO_2 in 2019. The industry sector contributes the most, at 37%, followed by transport (27%) and electricity and heat generation (27%).[160, 161] However, emissions from energy use are growing and are projected to comprise more than 50% of total emissions by 2030.[162] Because Indonesia has the world's fourth-largest population and its economy is growing, its energy consumption will continue to rise over the next decades.

[160] Climate Action Tracker (CAT). (2020). Indonesia. In CAT September 2020 Update. Berlin: Climate Analytics, New Climate Institute. https://climateactiontracker.org/countries/Indonesia/

[161] Gütschow, J. et al. (2019). The PRIMAP-hist national historical emissions time series (1850-2017), V.2.1. GFZ Data Services. https://doi.org/10.5880/PIK.2019.018

[162] BAPPENAS. 2015b. "Dokumen Pendukung Penyusunan INDC.

In 2015, the renewable energy share, excluding biomass, in Indonesia's national energy mix was only 4.38 percent.[163] As stated in its National Energy Policy, Indonesia aims to achieve a 23 percent share of renewable energy in the national energy mix by 2025, and 31 percent by 2050.[164]

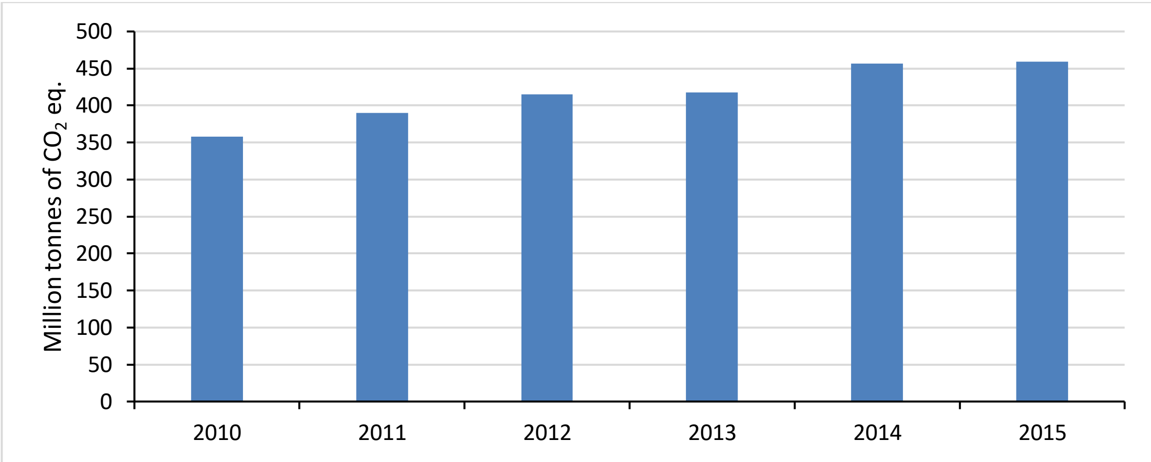

Figure 3-89 GHG emissions from energy use (2010 – 2015)

Greenhouse gas from agriculture

Indonesia has vast and abundant fertile soils Indonesia and is a major global key producer of a wide variety of agricultural tropical products. For this reason, the agriculture sector is an integral part of the Indonesian economy; for this reason, research on the effects of these sectors on GHG emissions is an important subject. GHG emissions contributed by agriculture have generally been increasing over the years in comparison to GHG from energy use, GHG from other sources as well as GHG total. These increments can be attributed to the expansion of agriculture as research and innovations in the agriculture sector keep growing within Indonesia. According to FAOSTAT, Indonesia's GHG emissions in 2018 amounted to 0.165 Mt CO_2eq where rice cultivation is the main producer of agricultural sector GHG emissions.[165]

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163 Ministry of Energy and Mineral Resources. 2016. "Handbook of Energy and Economics Statistics of Indonesia.

164 Government of Indonesia. 2014a. "Peraturan Pemerintah Republik Indonesia Nomor 79 Tahun 2014, Tentang Kebijakan Energi Nasional." http://peraturan.go.id/pp/nomor-79-tahun-2014.html

165 *Indonesia Agriculture Public Expenditure Review 2010*. (n.d.). Retrieved January 21, 2022, from https://documents1.worldbank.org/curated/en/297881468038713079/pdf/693460REVISED00000Version0201109050.pdf

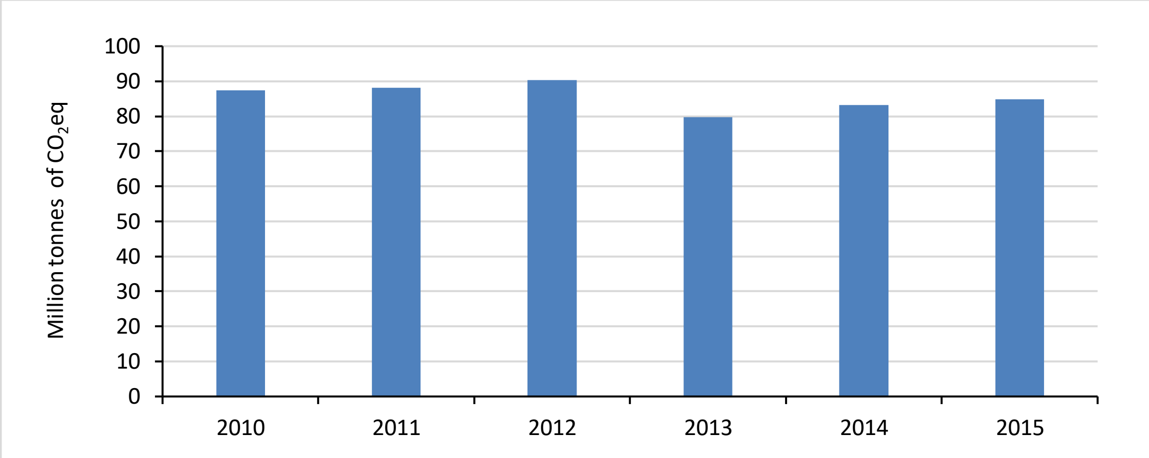

Figure 3-90 GHG from agriculture in Indonesia (2010 - 2015)

3.3.1.7 Material use and HDI

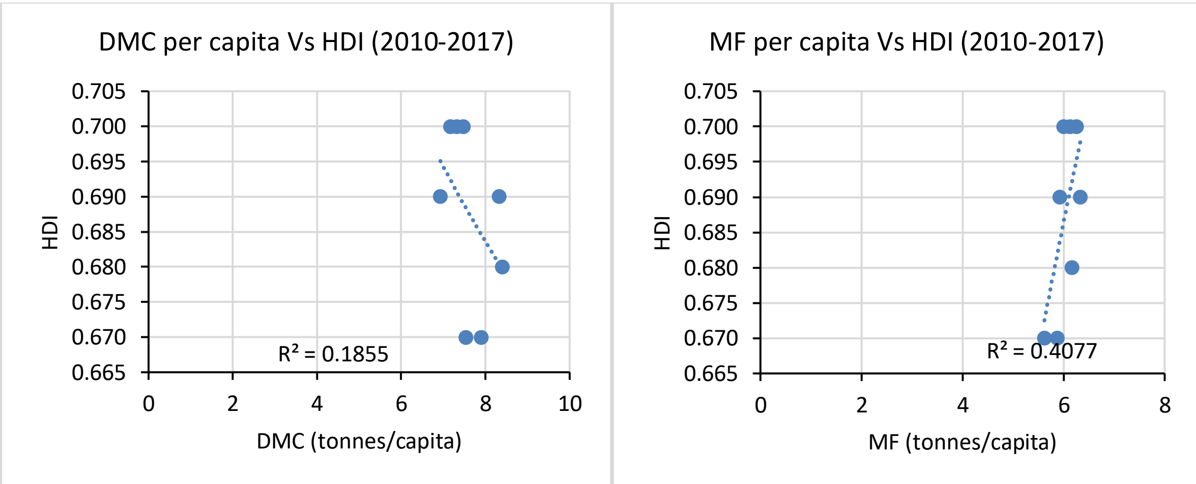

Figure 3-91 The relationship between material use (DMC per capita), and material footprint (MF per capita) versus the human development index (HDI) for Indonesia (2010-2017).

Figure 3-91 presents the relationship between DMC and HDI, and the relationship between the material footprint of consumption and HDI in Indonesia from 2010 to 2017. It can be seen from **Figure 3-91** that the correlation between DMC and HDI is negative and weaker while the correlation between material footprint and HDI is positive and much stronger as compared to DMC. It is also reflected in the value of correlation coefficient "*r*" as the value of *r* between DMC and HDI, and material footprint and HDI was -0.4257 and 0.6335, respectively, from 2010 to 2017. The reason may be the country is classified as a newly industrialized country. Moreover, the economy of Indonesia is the largest in Southeast Asia and the 15th largest in the world in terms of nominal GDP.[166] On the other hand, the average percentage share of services, industry, and agriculture sectors (the three most significant sectors in Indonesia's economy regarding GDP) in GDP was around 42.59%, 40.96%, and 13.35%, respectively, in Indonesia from 2010 to 2020.[167] It can be estimated from the before mentioned statistics that most of the income is generated by the services sector which is a less material-intensive sector as compared to the manufacturing industry, therefore, the relationship between DMC and HDI in Indonesia is weaker.

3.3.1.8 Economic growth

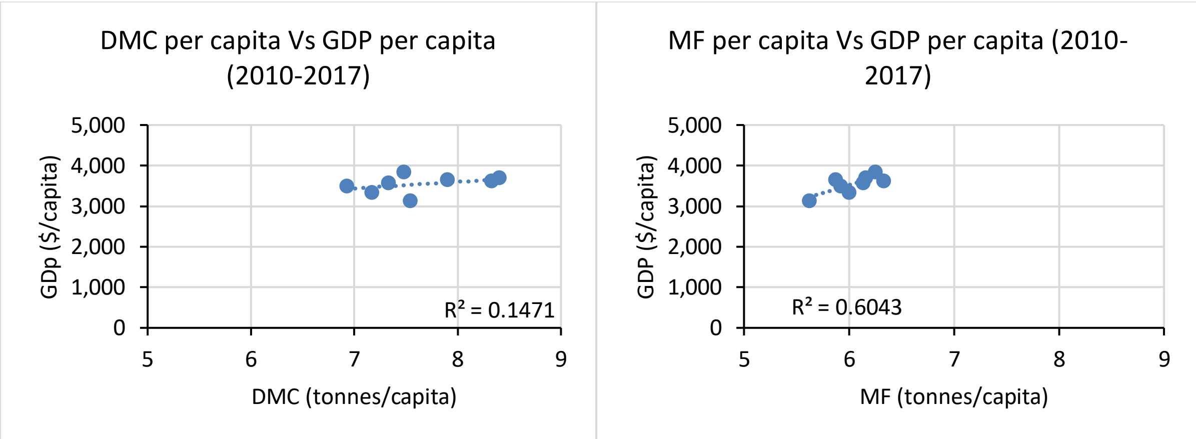

Figure 3-92 The relationship between material use (DMC per capita), and material footprint (MF per capita) versus the GDP per capita, Indonesia (2010, 2017)

In **Figure 3-92**, Indonesia's DMC per capita (tonnes/capita) and material footprint per capita (tonnes/capita) is plotted against GDP per capita for 2010 and 2017. It can be seen that both DMC per capita and material footprint per capita has a positive relationship with GDP per capita. However, for Indonesia, the correlation between DMC and GDP is quite weak as compared to material footprint and GDP as the value of correlation coefficient "*r*" between DMC and GDP, and material footprint and GDP was 0.3858 and 0.7737, respectively, from 2010 to 2017.

166 https://en.wikipedia.org/wiki/Economy_of_Indonesia
167 https://www.statista.com/statistics/319236/share-of-economic-sectors-in-the-gdp-in-indonesia/#:~:text=This%20statistic%20shows%20the%20share,sector%20contributed%20about%2044.4%20percent.

3.3.1.9 Physical trade balance

Agricultural sector

Indonesia is one of the world's agricultural nations, hence it was an agricultural exporter (**Figure 3-93**). Crops were the major exported agricultural products which accounted for 99% of the total. Important exported crops were palm oil, natural rubber, coffee, tea, and spices.[168] The exported crops declined by 35% in 2011 and the accelerated increase in 2012 and 2013 resulted from the government's plans for agriculture and food and nutrition security.[169] After 2013 exported crops decreased slowly by around 5% on average. The PTB per capita was -0.06 tonnes per capita in 2017 which increased by 0.02 in absolute value from 2010, as presented in **Figure 3-94**.

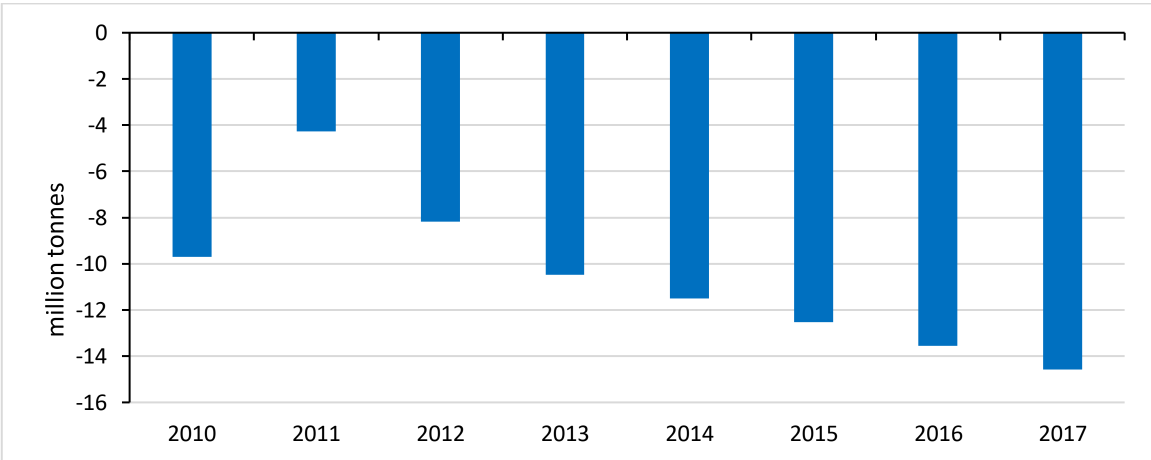

Figure 3-93 Physical trade balance by agricultural sector in Indonesia, 2010 to 2017

[168] Indonesia-Investments. (2015).
Agricultural Sector of Indonesia. Available at: https://www.indonesia-investments.com/culture/economy/general-economic-outline/agriculture/item378
[169] FAO (2017). *Country fact sheet on food and agriculture policy trends*. FAO. https://www.fao.org/3/i7696e/i7696e.pdf

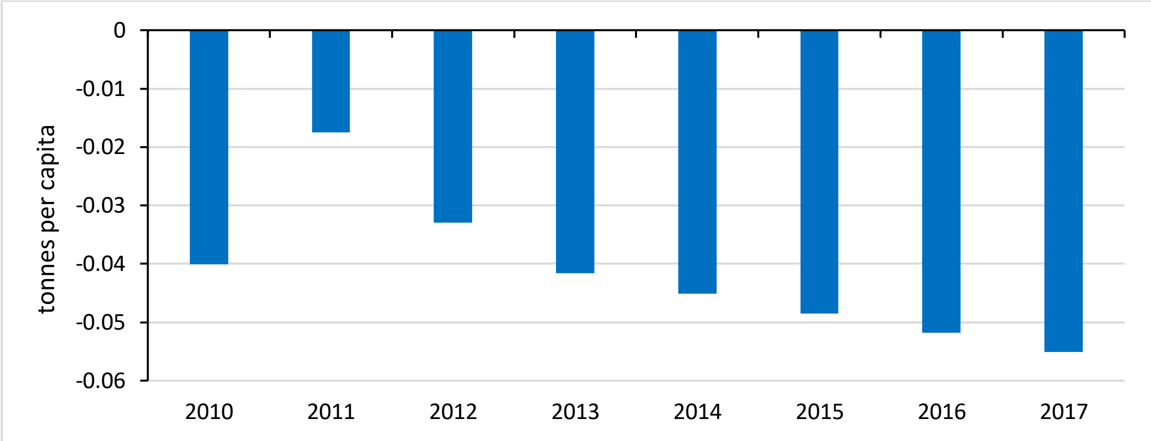

Figure 3-94 Physical trade balance per capita by agricultural sector in Indonesia, 2010 to 2017

Food sector

The deficit of the food sector in **Figure 3-95** decreased greatly by 107% in 2011 because of decreasing in its exported food volume in crops. This might result in the government implementing an export tax policy in 2010.[170] The shares of exported and imported food between crops and wild catch and harvest had not dramatically changed from 2010 to 2017. The crops have remained major exported and imported food in Indonesia. The PTB per capita was -0.06 tonnes per capita in 2017 which increased by 27% from 2010 (**Figure 3-96**).

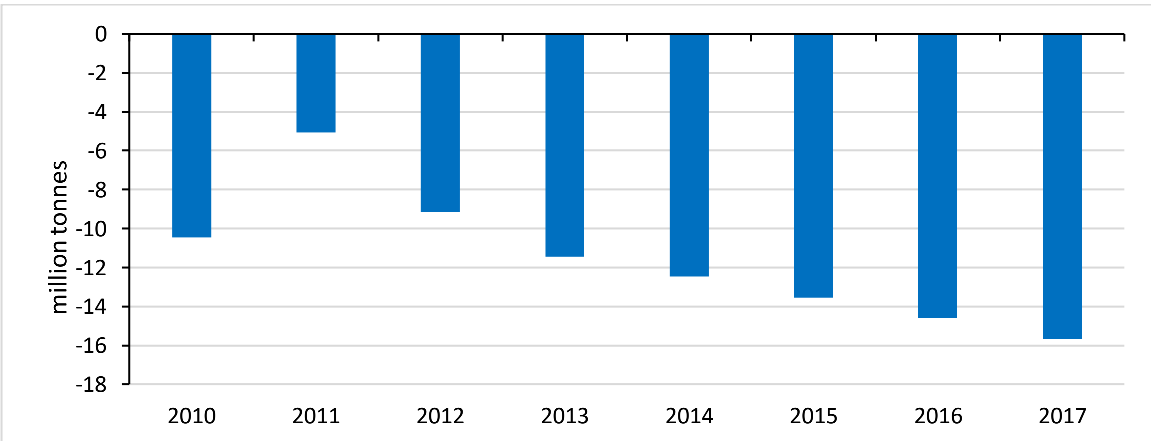

Figure 3-95 Physical trade balance by food sector in Indonesia, 2010 to 2017

[170] Refin, A., & Nauly, D. (2013). The Effect of Export Tax on Indonesia's Cocoa Export Competitiveness [Paper presentation]. The 57th AARES Annual Conference, Sydney, New South Wales.

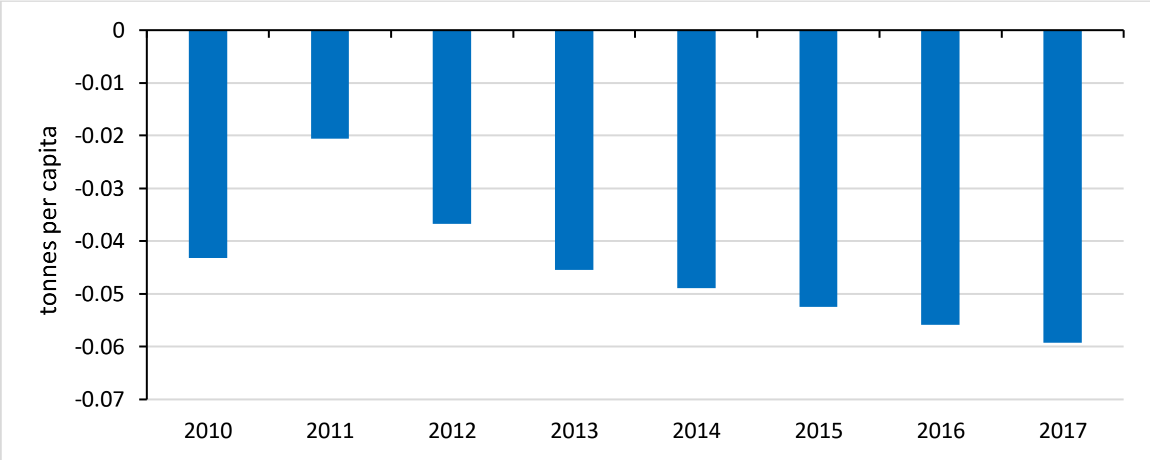

Figure 3-96 Physical trade balance per capita by food sector in Indonesia, 2010 to 2017

Construction sector

As shown in **Figure 3-97**, Indonesia faced large fluctuations in trade from 2012 to 2016 resulting from its unstable export volume from minerals in the construction sector becoming minor minerals.[171] It changed in net importer status in 2015. Indonesia's per capita trade in the construction sector was 0.03 tonnes per capita which were almost opposite from its PTB per capita in 2010 (**Figure 3-98**).

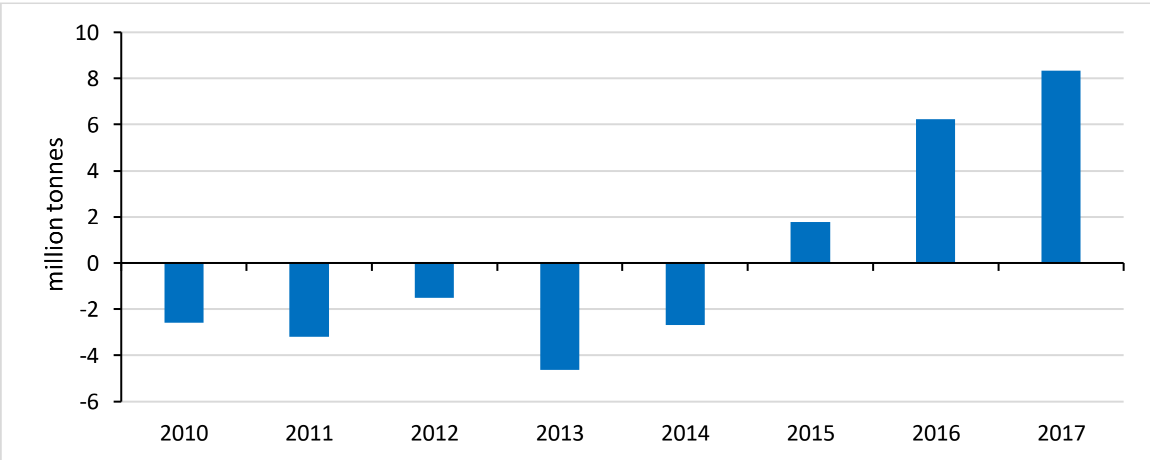

Figure 3-97 Physical trade balance by construction sector in Indonesia, 2010 to 2017

[171] BGR (2021). Construction Raw Materials in India and Indonesia Market Study and Potential Analysis | Final Report. Bundesanstalt für Geowissenschaften und Rohstoffe (BGR). https://rue.bmz.de/de/publikationen_aktuelles/publikationen_neu/themen/lokale_wertsch__pfung/Construction-Raw-Materials-in-India-and-Indonesia---Market-Study-and-Potential-Analysis_-Final-Report.pdf

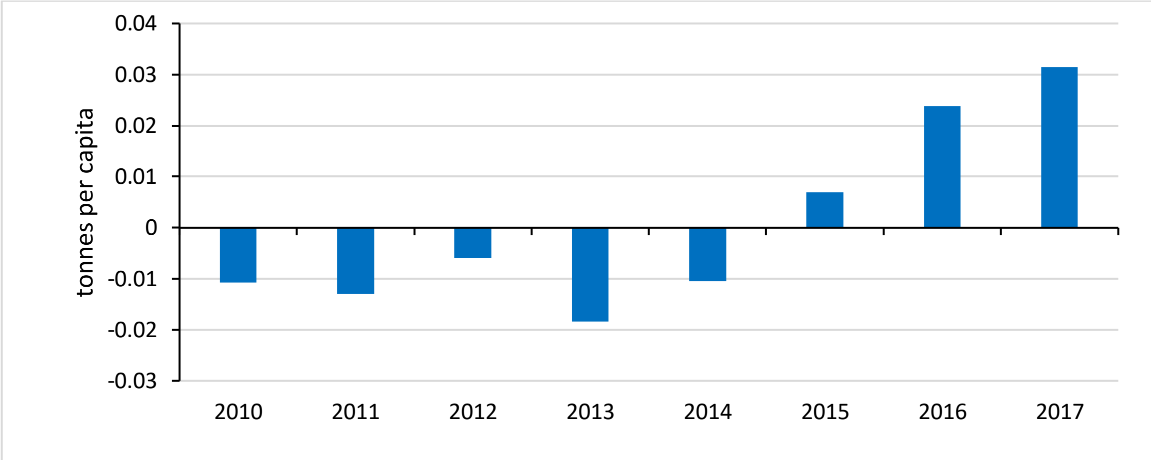

Figure 3-98 Physical trade balance per capita by construction sector in Indonesia, 2010 to 2017

3.3.2 Consolidated discussion

Indonesia is one of the world's largest exporters of agricultural products and its economy is mainly dependent on the industry sector and agriculture sector. The increase in material use, water use, energy use, and land use leads to soil degradation, resource shortages, and biodiversity loss. These impacts will cause damage to its economic growth and development. However, the comprehensive summary of SCP indicators and issues considering the DPSIR framework for Indonesia is presented in **Table 3-4**.

Table 3-4 A summary of SCP indicators and issues considering the DPSIR framework for Indonesia.

Derivers/ pressures	State/ impact	Responses
- Increasing population (173.52 million to 1181.41 million from 1990 to 2020) - The urban population has increased from around 31% in 1990 to 57% in 2020 - Increased economic activity	- Domestic material consumption increased from more than 1.8 billion tonnes in 2010 to around 2.0 billion tonnes in 2017. - DMC slightly decreased from 7.54 tonnes per capita in 2010 to 7.48 tonnes per capita in 2017.	- Long-Term Strategy for Low Carbon and Climate Resilience 2050 (Indonesia LTS-LCCR 2050) is guided by the principles of • reducing the impact of climate change on national GDP loss by 3.45% in 2050

Derivers/ pressures	State/ impact	Responses
• GDP climbed from 0.1 trillion USD in 1990 to 1.1 trillion USD in 2020. • GDP per capita raised from almost 585 USD in 1990 to 3,870 USD in 2020. - Massive industrialization after the year 2000 has caused a rapid increase in economic growth	- The material intensity of Indonesia was still 1.7 times higher than the overall world in 2017. - The installed renewable generation capacity increased from 21.7 to 36.4 watts per capita from 2001 to 2019 - The agriculture sector is the major contributor to land use and water use • Land use of the agriculture sector was 13.5 million hectares in 1990 which increased by 15.7 million hectares by the end of 2018. • Water use in Indonesia was 3.59 billion cubic meters in 2018. This decreased by 0.044 billion cubic meters compared to water use in 2010. - GHG emissions increased from 425 Mt CO_2eq in 1990 to 748 Mt CO_2eq in 2015 which contributed to: • Energy sector (67%), • Transportation (12%), and • Agriculture (11%) - The physical trade balance is negative for all the considered sectors except construction.	• increase resilience in four necessities (food, water, energy, and environmental health) with three target areas of resilience (economy, social and livelihood, ecosystem, and landscape). - Indonesia's Development Planning (RPJMN 2020-2024) has seven development agendas aligned with the SDGs. For examples, • Agenda 1: to improve the quality and competitiveness of the human resources (SDGs 1-5) • Agenda 7: to rebuild the living environment and increase the • resilience towards disaster and climate change (SDGs 11-15)

3.4 Pakistan

- Pakistan is the fifth-most populous country in the world.
- The water use footprint of the agriculture and construction sectors decreased from 2010 to 2018.
- The land use footprint of the agriculture and food sectors in Pakistan showed a decrease from 1990 to 2018.
- Despite tremendous improvement, the material intensity of Pakistan is still 2.5 times higher than the overall world's material intensity.

Pakistan — official name Islamic Republic of Pakistan — is a country located in South Asia that has a long coastline along the Arabian Sea and Gulf of Oman in the south. It is surrounded by India on its eastern border, Afghanistan on its western border, Iran on its southwest border, and China on its northeast border.[172] It occupies a total area of 881,913 sq. km (or 340,509 sq. miles) and is the fifth-most populous country in the world (consisting of a total population of 220 million people) with an annual growth rate of 2.0%.[1,173]

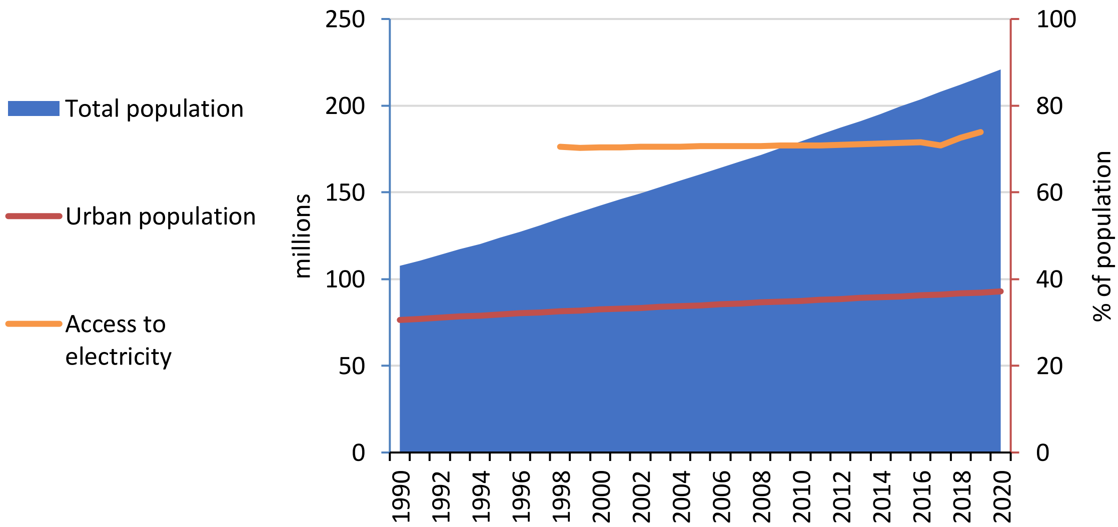

Figure 3-99 Total population, urban population, and population having access to electricity

[172] Ziring, L., and Burki, S. J. (2022) "Pakistan". Encyclopedia Britannica. Available at: https://www.britannica.com/place/Pakistan
[173] The World Bank. (2020). World Development Indicators. *The World Bank database.* Retrieved on, January 23, 2022, from https://data.worldbank.org/indicator

Figure 3-99 depicts the fast increase in the population of Pakistan over the last three decades, from 107 million in 1990 to 220 million in 2020, a jump of more than 100%. On the other hand, about 73 percent of the population has access to electricity, while those who live in urban areas make for nearly 37 percent of the entire population of the nation.

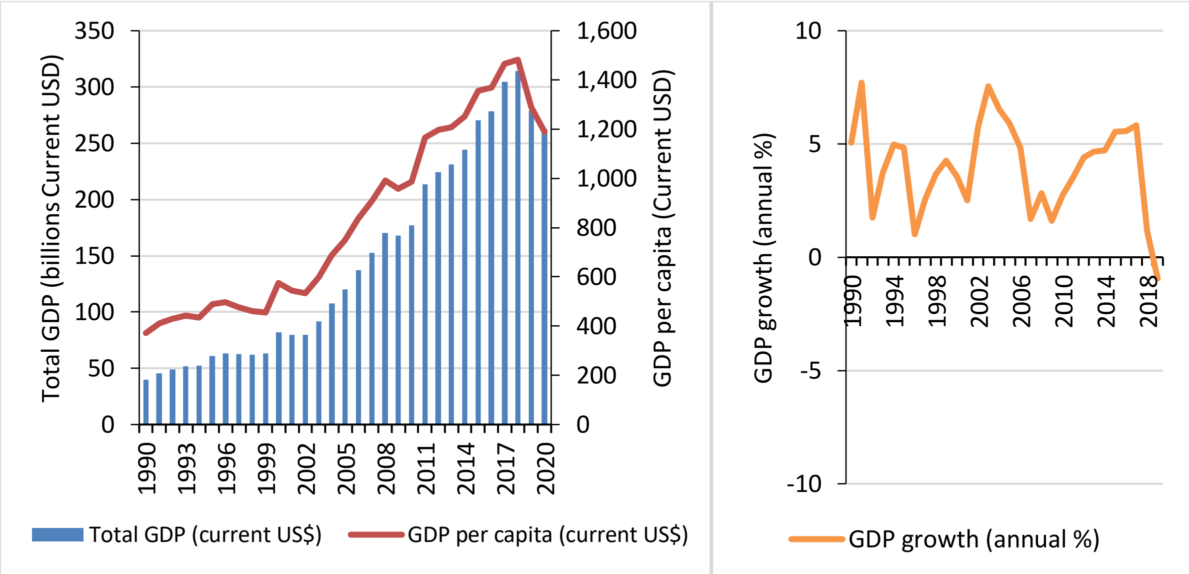

Figure 3-100 Total GDP, GDP per capita, and GDP annual growth[174]

Rice, wheat, cotton, and sugarcane are the major commodities belonging to the agriculture sector of the country. Major economic growth can be observed after 2000 as presented in **Figure 3-100**. During the past three decades between 1990 to 2018, the GDP of the country has been increased by many folds, i.e., from 40 billion to 315 billion, and the per capita GDP raised from almost 370 USD in 1990 to 1484 USD in 2018. However, due to the pandemic, economic growth has shown a sharp decline after 2018. Pakistan's consumption and production patterns have risen in recent decades, causing resource depletion and pollution, and straining the ecosystem's regenerative and assimilative ability. As a result, local (like resource shortages) and global (like biodiversity loss and climate change) challenges have evolved or gotten worse. In this country report, a wide range of SCP indicators is explored in detail using the DPSIR framework, as seen in **Figure 3-101**.

[174] The World Bank. (2020). World Development Indicators. *The World Bank database.* Retrieved on, January 23, 2022, from https://data.worldbank.org/indicator

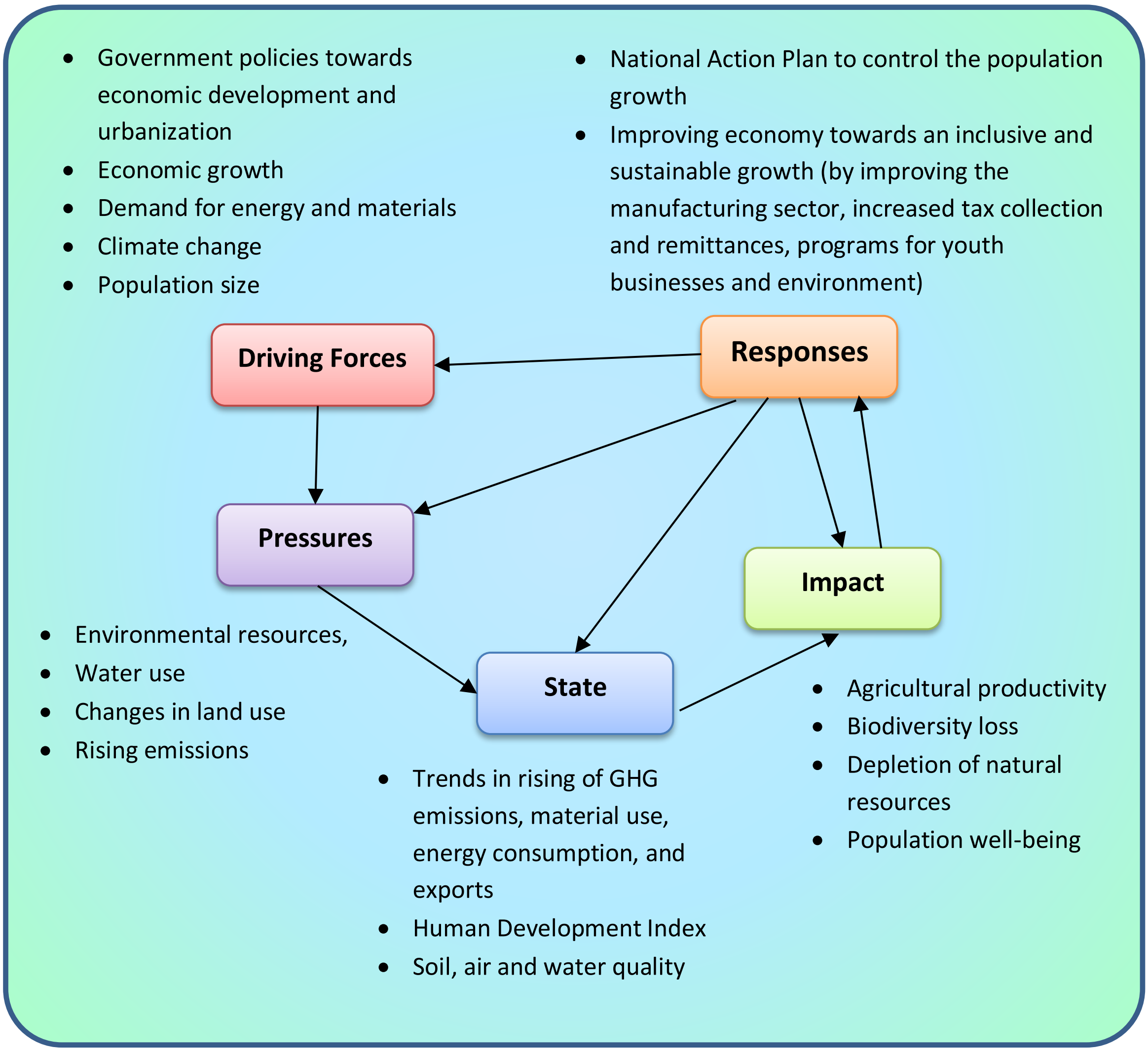

Figure 3-101 DPSIR framework for Pakistan

Sound Material-Cycle Society Law
A sustainable material-cycle society in which natural resource use is regulated and minimizes environmental impacts to the greatest extent is essential and practicable. The Fundamental Plan for Establishing a Sound Material Cycle Society, also known as Fundamental Law, was implemented in 2000. Following this law, the country has established four basic plans: The first, second, third, and fourth Fundamental Plan for Establishing a Sound Material-Cycle Society were enacted in 2003, 2008, 2013, and 2018 respectively. In the above-listed plans, the assigned indicators for achieving the purpose were continuously improved via thorough and systematic measures relating to the establishment of a sound material-cycle society. Furthermore, the plans were updated to address the issues with a focus on quantifying the values for material recycling and reducing waste generation. These amendments have all contributed to the formulation of the latest fundamental plan for 2025, "The 4th Fundamental Plan for Establishing a Sound Material-Cycle Society". The goal is to maximize recycling efforts while also addressing current challenges such as resource scarcity and environmental degradation. The list below presents a summary of the main work areas for the 4th Fundamental Plan of a Sound Material-Cycle Society of Japan. 1. Regional circular and ecological sphere: It aims to develop a multilayer resource circulation at an optimal scale. As a result, the resource cyclic use rate increased from 10% in 2000 to around 16% in 2015. The target is to increase it to 18% by the year 2025 (i.e., an 80% increase from the year 2000). 2. By supplying the necessary items and services to those in need when and in the proportions required, resource circulation can be maintained throughout the life cycle. Thus, the recycling rate for home appliances in the year 2014 was 92%, 75%, 89%, 80%, and 88% recycling rate for different homes gadgets. 3. Proper waste management and environmental restorations: To achieve this, the planned measures introduce stable and efficient waste treatment systems that create added value for the local community. Thus, in the year 2013, around 5340-kilo tonnes of waste material

were used for energy recovery where 3190-kilo tonnes of waste material were used for power generation.

4. Disaster waste management systems: Its goal is to strengthen waste management systems in normal times so that garbage can be treated quickly and properly in catastrophes.
5. International resource circulation: The goal of this pillar is to expand high-quality environmental infrastructure around the world by bringing together a collection of exceptional environmental technology, institutions, and systems.

3.4.1 Indicators

3.4.1.1 Water use

Water footprint in major sectors

Water is the main resource for manufacturing and production. As industrial progress is linked with GDP growth, that puts further pressure on water resources even after the decoupling efforts[175]. To analyze the hotspot sectors and the regions, the SCP Hotspots Analysis Tool (SCP-HAT) provides the blue water consumption footprint of multiple sectors. This section focuses on water use in five different sectors, viz., agriculture, food, tourism, construction, and transportation. The hotel and restaurants sector is used as a proxy for tourism.

Water footprint of agriculture sector

Water use footprint of the agriculture sector deals with the water use by food crops (wheat, maize, cereals, etc.), oil, fiber, non-perennial, spices, aromatic, drug and pharmaceutical crops, beverage crops, perennial crops, plant propagation, and water use in livestock farming based on consumption footprint[176]. The water use footprint of the agriculture sector of Pakistan decreased from 2010 to 2018. In 2018, the total water use footprint of Pakistan was 20.26 billion cubic meters per year. Overall, it decreased at the rate of 0.60 billion cubic

[175] UNEP (2015), Indicators for a Resource Efficient and Green Asia and the Pacific - Measuring progress of sustainable consumption and production, green economy and resource efficiency policies in the Asia-Pacific region, Schandl, H., West, J., Baynes, T., Hosking, K., Reinhardt, W., Geschke, A., Lenzen, M. United Nations Environment Programme, Bangkok.
[176] SCP-HAT (http://scp-hat.lifecycleinitiative.org/module-2-scp-hotspots/)

meters per year from 2010 to 2018. The decrease in the water use footprint of the agriculture sector even with the increase in land use in the agriculture sector is evidence of decoupling. It is possibly due to the use of modern efficient techniques of irrigation or change in crop types. Because one project funded by the World Bank, named "Punjab Irrigated-Agriculture Productivity Improvement Project", has been going on since 2008 to improve water use efficiency in agriculture fields[177]. The time series of water use footprint of the agriculture sector of Pakistan from 2010 to 2018 is shown in **Figure 3-102**.

Water footprint of food sector

Water use footprint of the food sector deals with the water used for processing, preserving, and manufacturing meat and fish-based products, cereal-based products, food crop products, mixed food and feed, cocoa, fiber-based products, chocolate and sugar confectionery, vegetable, and animal oils and fats, and manufacture of dairy products, alcoholic and other beverages, tobacco products based on consumption footprint. Water use footprint in the food sector of Pakistan showed an oscillating trend (decrease and then slight increase) from 2010 to 2018. On the whole, it was decreasing at an average rate of 0.91 billion cubic meters per year. In terms of percentage, it decreased by 8 percent from 2010 to 2018. The overall decrease in water use footprint in the food sector is possibly due to the variation in the agriculture sector. It is because the food sector is mainly linked with the agriculture sector. The time series of water use footprint in the food sector of Pakistan from 2010 to 2018 is shown in **Figure 3-102** and it is very clear that water use footprint follows the same pattern as the agriculture sector does.

Water footprint of construction sector

Water use footprint of the construction sector is defined as the water use in the construction of all buildings, roads and railways, utilities, and other civil engineering activities based on consumption footprint[178]. The water use footprint of the construction sector of Pakistan was increasing, it was increasing at the rate of 0.008 billion cubic meters per year from 2010 to 2018. In 2018, the total water use footprint of Pakistan was 0.15 billion cubic meters per year.

[177] http://ofwm.agripunjab.gov.pk/punjab_irrigated_agriculture_productivity
[178] SCP-HAT (http://scp-hat.lifecycleinitiative.org/module-2-scp-hotspots/)

In terms of percentage, it increased by 17 percent from 2010 to 2018. The overall increase in the water use footprint of the construction sector of Pakistan is possibly due to the increase in economic activities and population growth of the country. The time series of water use footprint of the construction sector of Pakistan from 2010 to 2018 is shown in **Figure 3-102**.

Water footprint of tourism sector

Water use footprint of the tourism sector is defined as the water use in hotels and restaurants for accommodation and food service activities based on consumption footprint[179]. The water use footprint of the tourism sector of Pakistan decreased from 2010 to 2018. In 2018, the total water use footprint of Pakistan was 0.42 billion cubic meters per year. From 2013 to 2015 it decreased sharply because the tourism activities were decreased in Pakistan at the same time, however it recovered after that. From 2013 to 2015 it decreased sharply because the tourism activities were decreased in Pakistan at the same time because of the security issues, especially, in the Northern part of the country[180], and it was low in 2018 due to a decline in GDP as shown in **Figure 3-102**. Land use under tourism in Pakistan also follows the pattern from 2010 to 2018. Overall, it decreased at the rate of 0.01 billion cubic meters per year from 2010 to 2018. The time series of water use footprint of the tourism sector of Pakistan from 2010 to 2018 is shown in **Figure 3-102**.

Water footprint of transport sector

Water use footprint in the transport sector is defined as the water use by land transport, water transport, air transport, transport via pipeline, warehousing, and support activities for transportation based on consumption footprint[181]. The water use footprint in the transport sector of Pakistan increased slightly with the rate of 0.0003 billion cubic meters per year from 2010 to 2018. In 2018, the total water use footprint in Pakistan was 0.06 billion cubic meters per year. The increase in water use in the transport sector was very little. The water use in the transport sector decreased slightly from 2010 to 2014, then it increased in 2015-17 and again it dropped in 2018. However, the drivers (population, economy, etc.) increased rapidly

179 SCP-HAT (http://scp-hat.lifecycleinitiative.org/module-2-scp-hotspots/)
180 https://www.ceicdata.com/en/indicator/pakistan/tourism-revenue-growth
181 SCP-HAT (http://scp-hat.lifecycleinitiative.org/module-2-scp-hotspots/)

at the same time. This weak correlation between water use footprint in the transport sector and drivers is showing the decoupling efforts of the policymakers. The time series of water use footprint in the transport sector of Pakistan from 2010 to 2018 is shown in **Figure 3-102**.

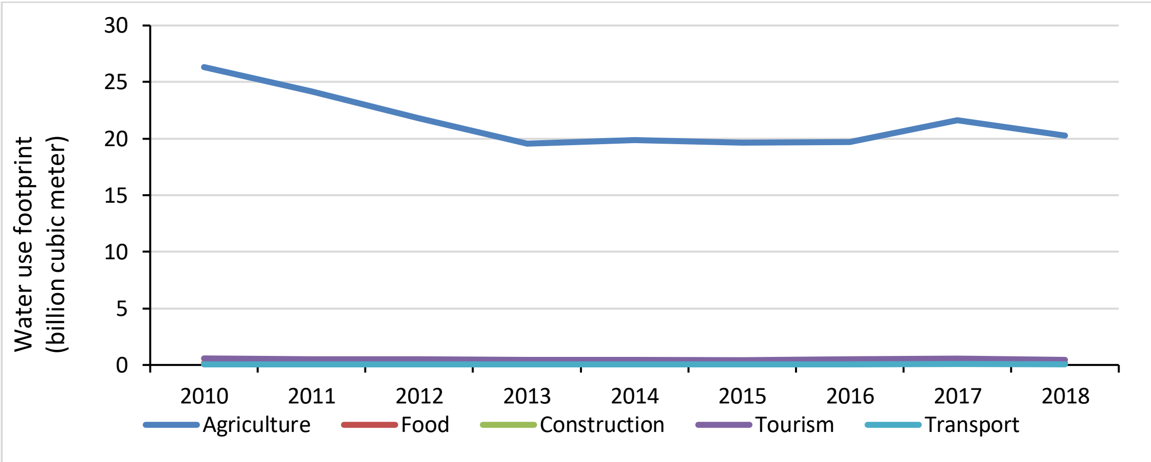

Figure 3-102 Water use footprint of five different sectors of Pakistan

Zero Wastewater discharge design practice at Al-Rahim Textile Industries (ATI), Pakistan
Pakistan is an agricultural country; however, it is facing a severe issue of economic problems, climate issues, energy shortages, and acute water availability. The textile sector of the country is a big source of foreign exchange. The current focus on sustainability by the foreign customers coupled with the enforcement of the strict regulations in the country has compelled the textile sector's stakeholders to implement sustainable consumption and production practices. Therefore, being competitive in the market and following the vision of the government requires the stakeholders to follow sustainable practices over the life cycle of products. The Zero Wastewater discharge design practice at Al-Rahim Textile Industries (ATI) is aimed at efficient utilization, recycling, conservation of water, and developing efficient wastewater treatment processes. The organization improved the water use efficiency by identifying the water use and pollution-intensive processes/ materials and exploiting potential opportunities (i.e. water conservation and pollution control).

Zero Wastewater discharge design practice at Al-Rahim Textile Industries (ATI), Pakistan
The water consumption at exhaust bleaching and dyeing processes was highly excessive where the freshwater use was around 600 liters per rinse/flush. However, it was found that the same process can be carried out using only around 300 liters per rinse/flush (i.e. 50% reduction). The other such examples were the reduction of around 6-7 m3/ hr of water consumption by changing the manual uncontrolled water flow with controlled mechanized controlled Waterflow, freshwater recovery of around 4.7 m3/hr by fixing the pump failure at mercerize machine, and reduction of freshwater use by around 2.2 m3/hr by adjusting the faulty automatic feedwater control valve, etc. - By implementing the newly developed Processing Water Management System, process water consumption was reduced to 18% (i.e. around 8,00 m3/day). - A treatment and handling method of reverse osmosis membranes rejecting water was developed. - Consequently, around 60-65% of the wastewater was being treated and re-used daily.

3.4.1.2 Land use

Land footprint in major sectors

Human progress has developed at an ever-increasing rate throughout modern history. As a result, there have been extraordinary shifts in land use. The change in different land-use types is driven by growth in population, GDP, food requirements, etc. To analyze the hotspot sectors and the regions, the SCP Hotspots Analysis Tool (SCP-HAT) provides the land use footprint of multiple sectors. This section is focusing land use in five different sectors viz., agriculture, food, tourism, construction, and transportation; in this report, the hotel and restaurants sector is used as a proxy for tourism.

Land use footprint in agriculture sector

Land use footprint of the agriculture sector deals with the land used for the cultivation of food crops (wheat, maize, cereals, etc.), oil, fiber, non-perennial, spices, aromatic, drug and pharmaceutical, crop beverage crops, perennial crops, plant propagation, and land use in livestock farming based on consumption footprint[182]. Land use footprint of the agriculture sector in Pakistan showed a decrease from 1990 to 2018. In 1990, the land use footprint of the agriculture sector in Pakistan was 10.96 million hectares which decreased by 4.24 million hectares by the end of 2018. The highest land use footprint of the agriculture sector was noticed in 1997 at 12.85 million hectares. Then it decreased thereafter due to natural calamities. Overall, it decreased at the rate of 0.1437 million hectares per year from 1990 to 2018. The decrease in land use footprint from 2001-2005 in the agriculture sector is more likely due to the severe drought in 2001-2002 within upcoming years as well. The time series of land use footprint of the agriculture sector of Pakistan from 1990 to 2018 is shown in **Figure 3-103**.

Land use footprint in food sector

Land use footprint of the food sector deals with the land use for processing, preserving, and manufacturing of meat and fish-based products, cereal-based products, food crop products, mixed food and feed, cocoa, fiber-based products, chocolate and sugar confectionery, vegetable, and animal oils and fats, and manufacture of dairy products, alcoholic and other beverages, tobacco products based on consumption footprint[183]. Land use footprint of the food sector of Pakistan showed decreasing trends from 1990 to 2018. In 1990, the land use footprint of the food sector in Pakistan was 13.72 million hectares which were decreased by 3.35 million hectares by the end of 2018. The highest land use footprint of the food sector was noticed in 1996 at 13.10 million hectares. Overall, it was decreasing at the rate of 0.147 million hectares per year from 1990 to 2018. The decrease in land use footprint of the food sector was perhaps due to the severe drought in 2001-02 in Pakistan and its effects were felt in the subsequent years as well. The floods in 2009, 2010, and 2011 decreased the land use footprint of the food sector in these years. The time series of land use footprint of the food sector of Pakistan land from 1990 to 2018 is shown in **Figure 3-103**.

[182] SCP-HAT (http://scp-hat.lifecycleinitiative.org/module-2-scp-hotspots/)
[183] SCP-HAT (http://scp-hat.lifecycleinitiative.org/module-2-scp-hotspots/)

Land use footprint in construction sector

Land use footprint of the construction sector is defined as the land use in the construction of all buildings, roads and railways, utilities, and other civil engineering activities based on consumption footprint[184]. Land use in the construction sector of Pakistan showed a slight increase from 1990 to 2018. In 1990, the land use footprint of the construction sector in Pakistan was 0.08 million hectares which increased by 0.11 million hectares by the end of 2018. The highest land use footprint of the construction sector was noticed in 2001, 2017, and 2018 at 0.19 million hectares. Overall, it was increasing at the rate of 0.0032 million hectares per year from 1990 to 2018. For land use footprint in the construction sector was the highest in 2001, perhaps due to the utilizing Pakistan as a passage corridor by the United States and allied armies at the start of the Afghan war in 2001. The increase in land use footprint of the construction sector is possibly due to rapid urbanization. The time series of land use footprint of the construction sector of Pakistan land from 1990 to 2018 is shown in **Figure 3-103**.

Land use footprint in transport sector

Land use footprint of the transport sector is defined as land use by land transport, water transport, air transport, transport via pipeline, warehousing, and support activities for transportation based on consumption footprint[185]. Land use footprint of the transport sector in Pakistan was showing oscillating trends from 1990 to 2018. In 1990 the land use of the transport sector in Pakistan was 0.07 million hectares which increased by 0.02 million hectares by the end of 2018. The highest land use footprint of the transport sector was noticed in 2001 was 0.21 million hectares. Overall, it increased at the rate of 0.0015 million hectares per year from 1990 to 2018. For land use footprint in the transport sector, 2001 was an exceptional year perhaps due to the utilization of Pakistan as a passage corridor by the United States and allied armies at the start of the Afghan war 2001. The increase in land use in the transport sector is probably due to the increase in economic development and

[184] SCP-HAT (http://scp-hat.lifecycleinitiative.org/module-2-scp-hotspots/)
[185] SCP-HAT (http://scp-hat.lifecycleinitiative.org/module-2-scp-hotspots/)

population expansion. The time series of land use footprint of the transport sector of Pakistan from 1990 to 2018 is shown in **Figure 3-103**.

Land use footprint in tourism sector

Land use footprint in the tourism sector is defined as the land use in hotels and restaurants for accommodation and food service activities based on consumption footprint[186]. Land use footprint of the tourism sector in Pakistan was showing an increase slightly in the first decade of this century then it declines slightly in the next decade. In 1990 the land use footprint of the tourism sector in Pakistan was 0.59 million hectares which were decreased by 0.05 million hectares by the end of 2018. The highest land use footprint of the tourism sector was noticed in 2001 which was 3.36 million hectares. As discussed before 2001 was an exceptional year for Pakistan because of the start of the Afghan war. In 2001 there were a lot of war activities and hundreds of refugees came to Pakistan from Afghanistan[187]. Overall, there seems to be a constant trend from 1990 to 2018. The time series of land use footprint of the tourism sector of Pakistan land from 1990 to 2018 is shown in **Figure 3-103**.

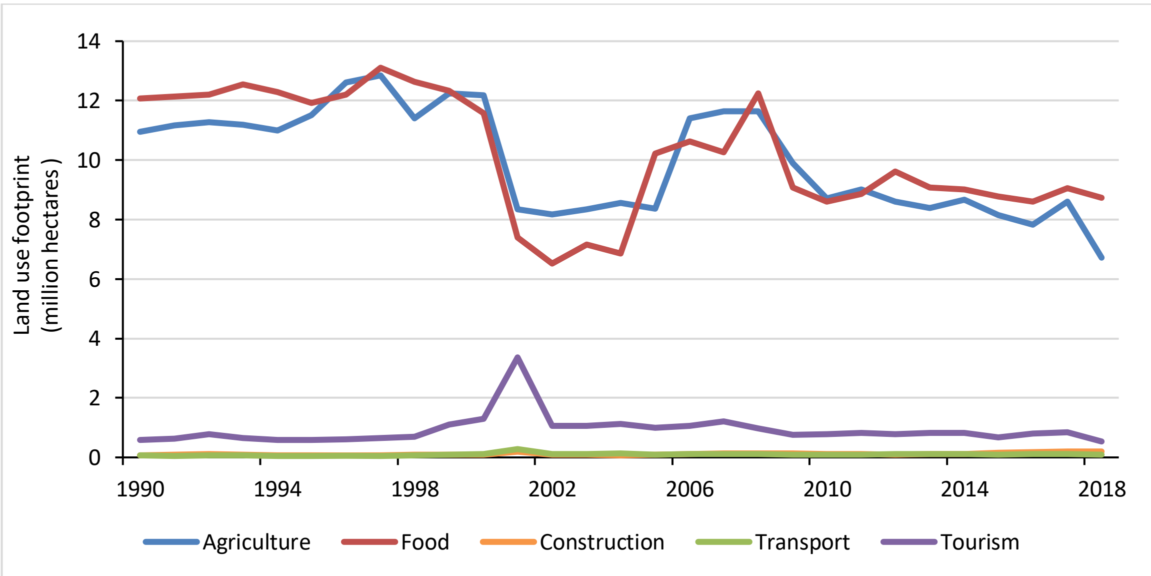

Figure 3-103 Land use footprint of five different sectors of Pakistan

[186] SCP-HAT (http://scp-hat.lifecycleinitiative.org/module-2-scp-hotspots/)
[187] https://interactive.aljazeera.com/aje/2021/afghanistan-refugees-karachi/index.html

3.4.1.3 Material Use

The total domestic material consumption (DMC, tonnes) and domestic material consumption per capita (DMC per capita, tonnes per capita) are used as indicators to measure material use. Further, the material use is classified into four main material categories and 13 subcategories as shown in **Table 3-5**. The time series here covers the period 2010 to 2017.

Table 3-5 The four categories of materials included in domestic material consumption, with decomposition into 13 subcategories[188], [189]

Main material categories	Thirteen subcategories
Biomass	Crops Crops residue Wood Animal products Grazed biomass Fodder crops
Fossil fuels	Coal Petroleum Natural gas
Metal ores	Ferrous ores Non-ferrous ores
Non-metallic minerals	Industrial minerals Construction minerals

Figure 3-104 shows the DMC of Pakistan from 2010 to 2017. The total DMC in Pakistan has increased from around 0.7 billion tonnes to around 0.9 billion tonnes in just seven years. The overall increase in the country's DMC was 32%. The reason behind this increase is possibly

[188] CSIRO (2018). Technical annex for Global Material Flows Database. UN Environment Programme. Available at https://www.csiro.au/~/media/LWF/Files/CES-Material-Flows_db/Technical-annex-for-Global-Material-Flows-Database.pdf
[189] Li, N., Zhang, T., Qi,J., & Huang,Y. (2015). Using Multiple Tools to Analyze Resource Exchange in China. Sustainability, 7, 12372-12385. https://doi.org/10.3390/su70912372

the increase in population. The country's population increased to around 208 million in 2017 from 179 million in 2010. Another reason could be the enhanced economic activities that caused a tremendous increase in the country's gross domestic product (GDP) which is 72% from 2010 to 2017.

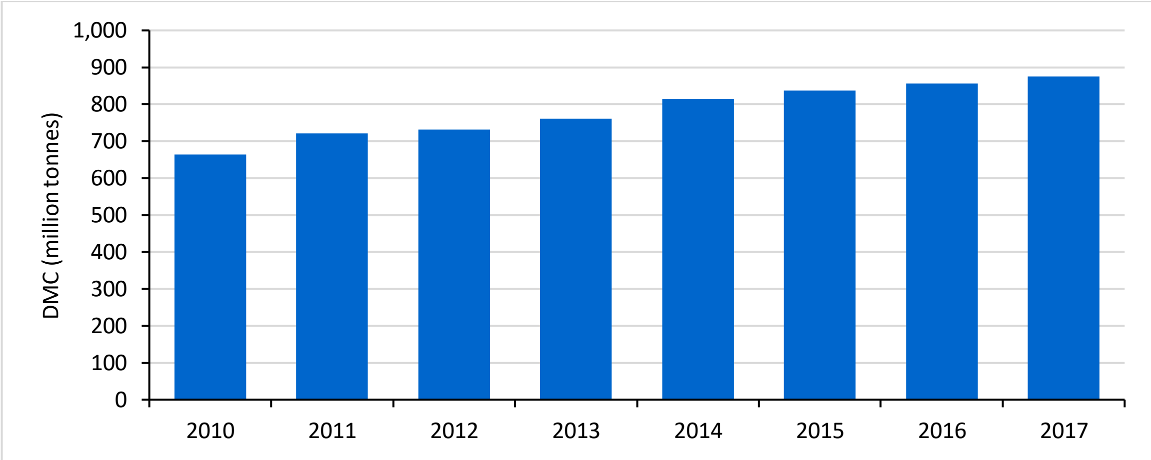

Figure 3-104 Domestic material consumption in Pakistan (2010 – 2017)

Figure 3-105 shows the per capita DMC of Pakistan from 2010 to 2017. **Figure 3-105** also presents the per capita DMC of Asia and the World for the same period. It can be seen that the country's per capita DMC is almost three times lower as compared to the per capita DMC in Asia and the World. Moreover, from 2010 t0 2017, the country's per capita DMC slightly increased despite a noticeable increase in the overall DMC as presented in **Figure 3-105**. In 2010, the country's per capita DMC was 3.89 tonnes per capita which increased by a rate of 14% and reached 4.45 tonnes per capita in 2017. This is because of the rapid increase in the country's population which increased from 179 million in 2010 to around 208 million in 2017.

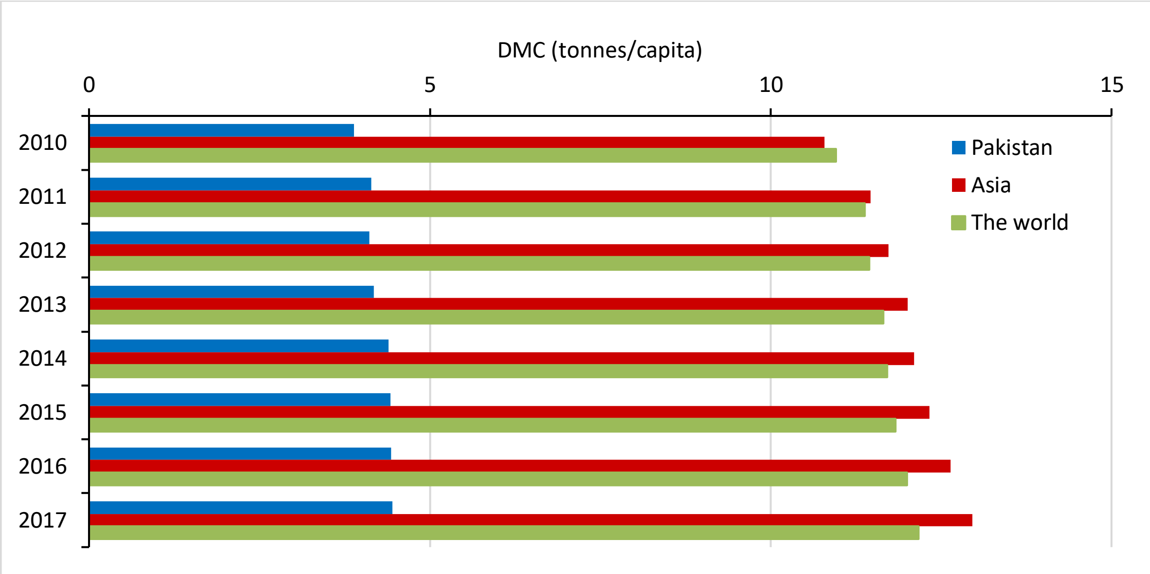

Figure 3-105 Per capita domestic material consumption in Pakistan, Asia, and the World (2010-2017)[190]

Figure 3-106 presents the category-wise DMC in Pakistan. It can be seen that different material categories show different growth trajectories. From 2010 to 2017, the average annual growth in DMC of biomass, fossil fuels, and non-metal minerals has increased at a rate of 0.025%, 0.017%, and 0.071%, respectively, while the DMC of metal ores decreased in the country at a rate of 0.014%. It has been observed that the percentage growth in non-metallic minerals consumption is highest among all four material categories, followed by biomass. The total annual DMC of biomass, fossil fuels, metal ores, and non-metallic minerals has experienced an increase of 22%, 15%, -11%, and, 76% in 2017 as compared to 2010. These statistics indicate that Pakistan's economy is moving away from the biomass-based materials and energy systems and adopting the mineral-based systems of industrial economies as the overall growth in non-metallic minerals consumption is more than three folds higher as compared to biomass from 2010 to 2017. The different growth patterns of the different material categories exhibit that the country is undergoing a transition from advanced agrarian economy to industrialized society.

[190] UNEP databank. (https://uneplive.unep.org/downloader).

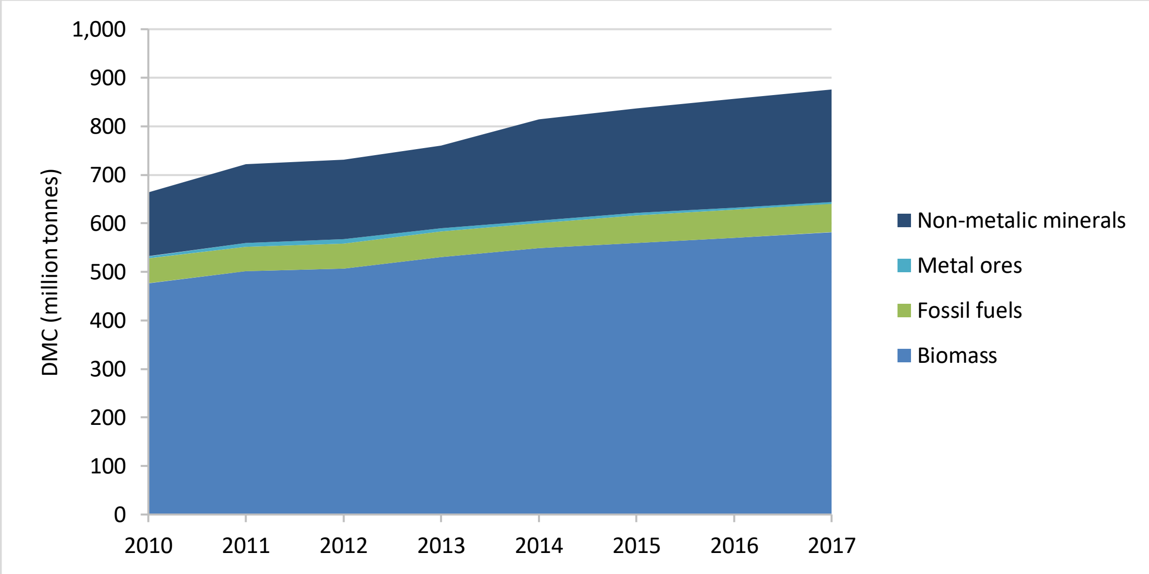

Figure 3-106 Domestic material consumption by material category in Pakistan (2010 – 2017)

Material use by major sectors

Figure 3-107 shows the sector-wise material footprint of consumption in Pakistan. **Figure 3-107** shows that the food sector has the highest material consumption. The sector has experienced continuous growth from 2010 to 2017. However, a decline has been noticed in material consumption of Pakistan's food sector from 2017 to 2018. On the other hand, the manufacturing sector (the second most significant regarding material consumption) in the country has experienced a sharp increase in its material consumption. This may be because of the country's improved efforts to boost its shift from an advanced agriculture economy to a modernized industrial state. The sectors including agriculture, construction, tourism, and transport are the bottom four sectors regarding material consumption. Despite being an agriculture-based economy, the low material consumption of Pakistan's agriculture sector maybe because of the adoption of conventional agricultural techniques and technologies. On the other hand, the least material consumption by the construction, tourism, and transport sectors shows the passive development activities for infrastructure development in the country. Another reason may be the internal political instability and unpleasant relationship of Pakistan with the neighboring countries.

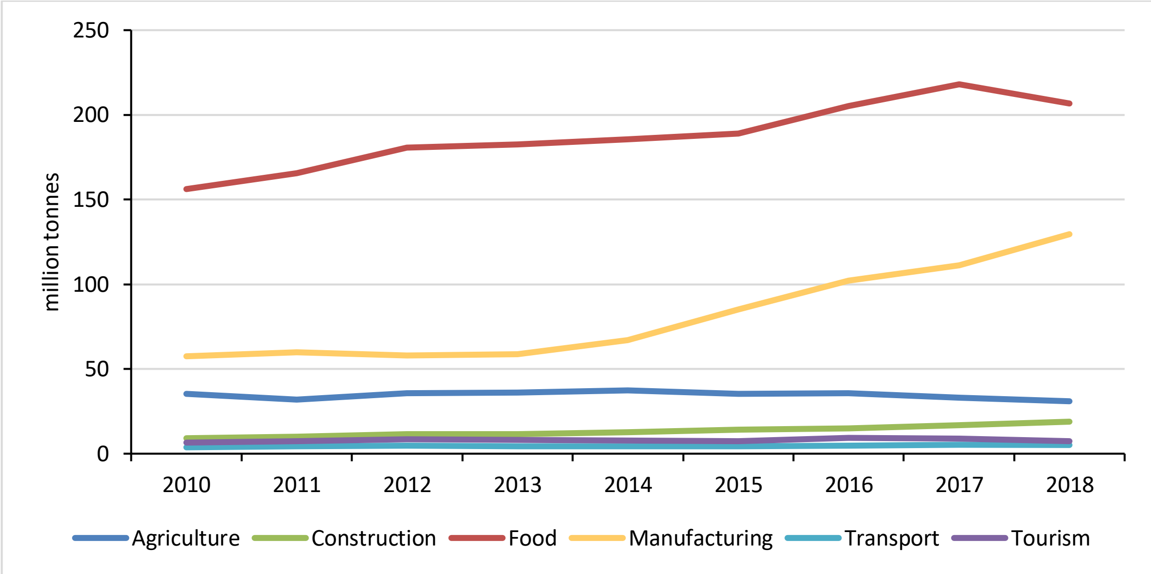

Figure 3-107 Sector-wise material footprint in Pakistan (2010-2018)

Material Intensity

Figure 3-108 exhibits the comparison of material intensity (kg per $) between Pakistan, Asia, and the world. The material intensity of the world remained almost constant from 2010 to 2017. On the other hand, there was a tremendous improvement in the material intensity of Pakistan, and overall, around the Asian region, the amount of material to produce one US$ in terms of GDP has decreased by around 24% and 29%, respectively, from 2010 to 2017. Despite this huge improvement, the material intensity of Pakistan and the overall Asian region is still 2.5 times and 2.4 times higher than the overall world's material intensity, respectively. This passiveness of the Asian region in terms of material intensity is due to the consumption of natural resources in conventional ways. It shows that the Asia Pacific developing region still has to go a long way to attain the material intensity to compete with the industrialized world. This can be done by adopting innovative urban development, advanced modes of transportation, efficient energy production, and a modern economic structure.

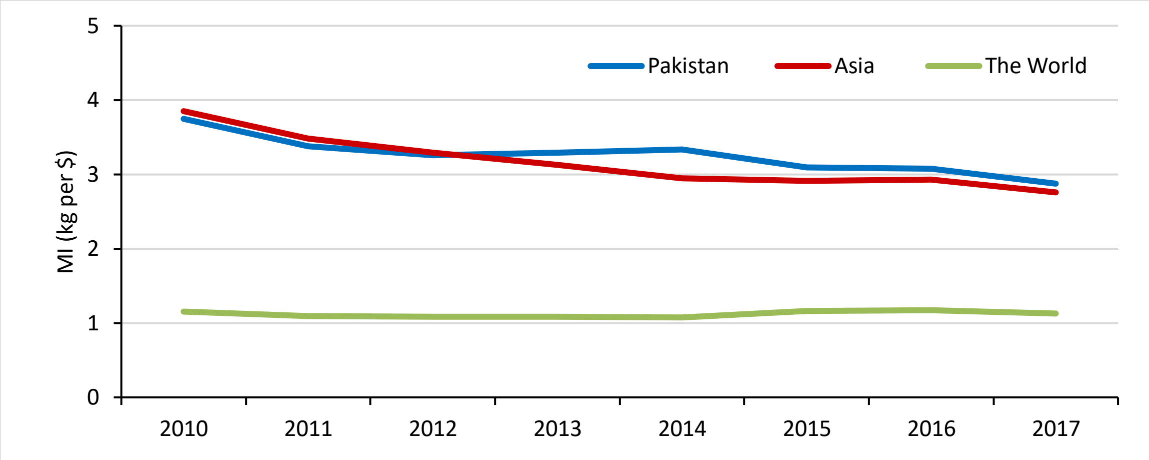

Figure 3-108 Material intensity for Pakistan, Asia, and the World (2010 – 2017)

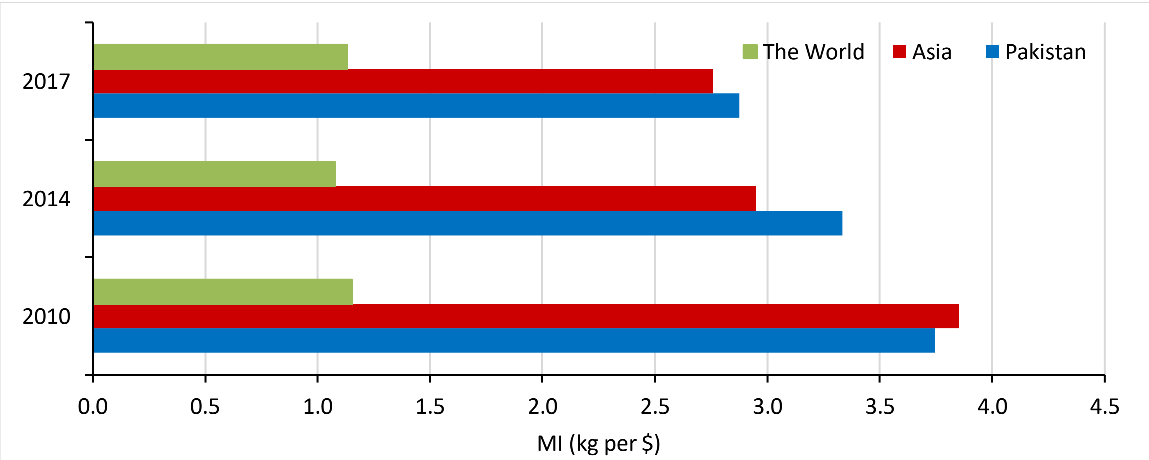

Figure 3-109 Material intensity for Pakistan, Asia, and the World (2010, 2014, 2017)

Figure 3-109 compares the material intensity of Pakistan with the material intensity of Asia as well as the whole world. It can be seen that Pakistan's material intensity was lower as compared to overall Asia in 2010. Despite a prominent change in the country's material intensity, it was higher as compared to the overall Asian region in 2014 and 2017. The external reason behind this gap in the material efficiency of Pakistan and the Asian region may be the adoption of more efficient production systems and technological development in industrial Asian countries (Singapore, Korea, Japan, China, etc.). While the internal reason may be the political and economic instability in the country. On the other hand, the material intensity of Pakistan as well as the overall Asian region remained higher when compared to the overall World's material intensity during the previous decade. This shows that the whole Asian region has to adopt more efficient consumption and production patterns to achieve decoupling, which is much needed indeed.

Material footprint of consumption

Figure 3-110 shows the material footprint of consumption in Pakistan. It can be seen that the material footprint of consumption has continuously increased from less than 500 million tonnes in 2010 to more than 600 million tonnes in 2017. The country experienced an overall increase of more than 27% in the domestic material footprint of consumption. This rapid growth in Pakistan's material footprint of consumption also reflects the immense growth of GDP in the country. In 2010, the total GDP of Pakistan was $US 177 billion that increased by 72% in 2017 to reach $US 305 billion. The increase in both the material footprint of consumption and the GDP of Pakistan shows an immense increase in production activities in the country.

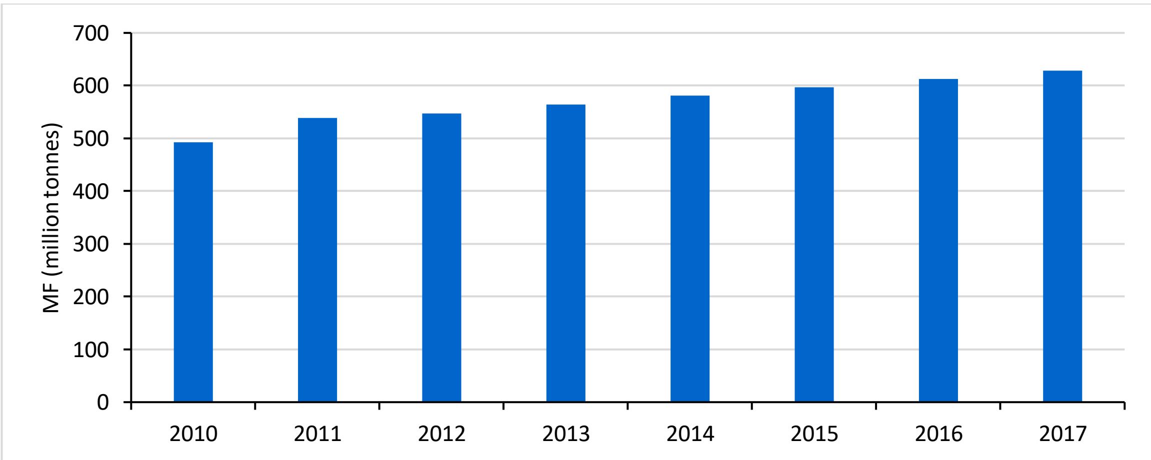

Figure 3-110 Material footprint of consumption in Pakistan (2010 – 2017)

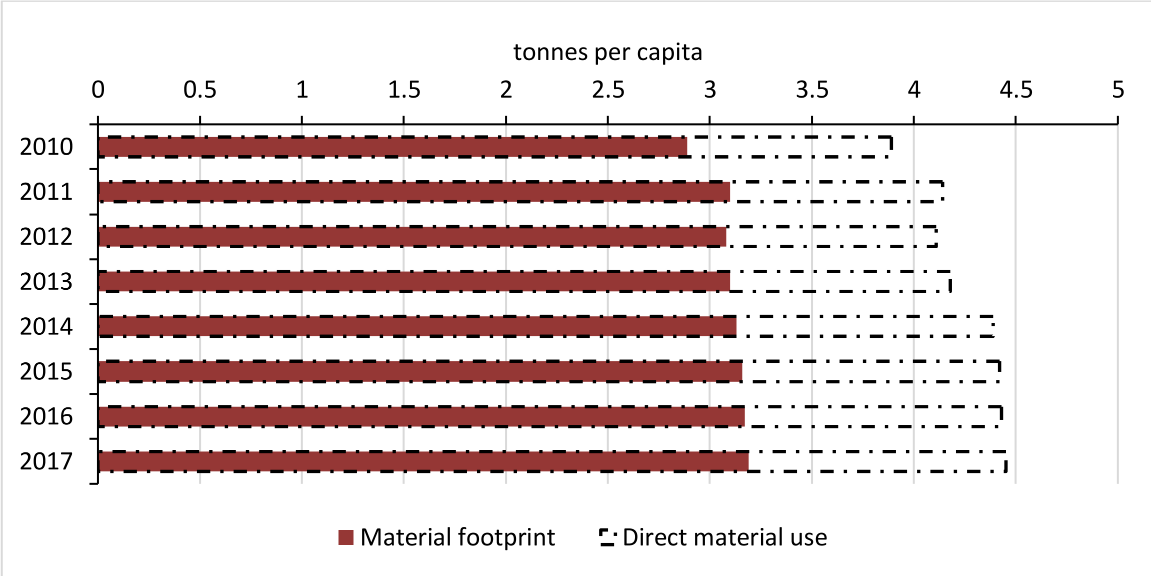

Figure 3-111 Material footprint per capita compared to domestic material consumption per capita in Pakistan (2010-2017)

Figure 3-111 compares the material footprint per capita with the DMC per capita of Pakistan from 2010 to 2017. The DMC is associated with large extraction and significant manufacturing activities while the material footprint represents the material consumption for the production systems. It can be seen from **Figure 3-111** that Pakistan has a higher DMC per capita as compared to material footprint per capita from 2010 to 2017. This is because the country is an agriculture-based economy and earns most of its foreign exchange from the export of agricultural products. However, there is no doubt that the country has attained a higher standard of living as their material use for the production sector is higher which provides substantial opportunities for employment creation and income generation.

3.4.1.4 Energy use

Pakistan is developing policies, strategies, and programs to ensure that the country's energy supply is clean, inexpensive, and long-term, with a higher proportion of renewable energy in the mix. Pakistan's long-term growth strategy includes these energy supply strategies. To meet future growth in electricity demand, the government is preparing to tap into additional energy resources, including renewables. In terms of final energy consumption, the residential, industrial, and transport sectors are the most important, as illustrated in **Figure 3-112**. As a result, the electricity sector has been concentrating on integrating renewable energy into the national system. Ongoing policy reforms, regulatory changes, infrastructure development, and investment incentives are all geared at assuring a clean, affordable, and stable energy supply in the future, with a steadily rising percentage of renewable energy sources which is evident from **Figure 3-112**.

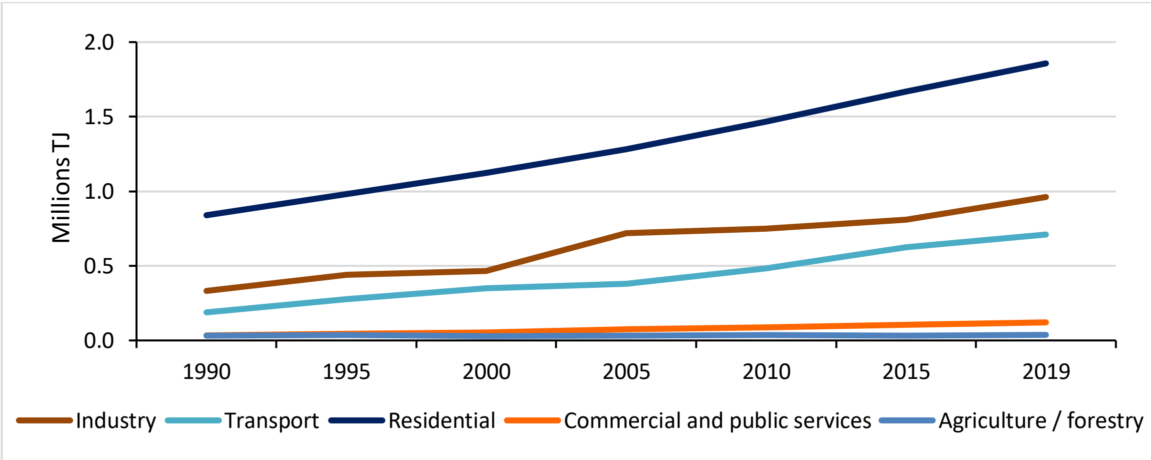

Figure 3-112 Sectoral share in total final energy consumption in Pakistan (1990-2019) [191]

[191] IEA. (2022). International Energy Agency. Retrieved from https://www.iea.org/data-and-statistics/data-browser?country=WORLD&fuel=Energy%20consumption&indicator=TFCShareBySector

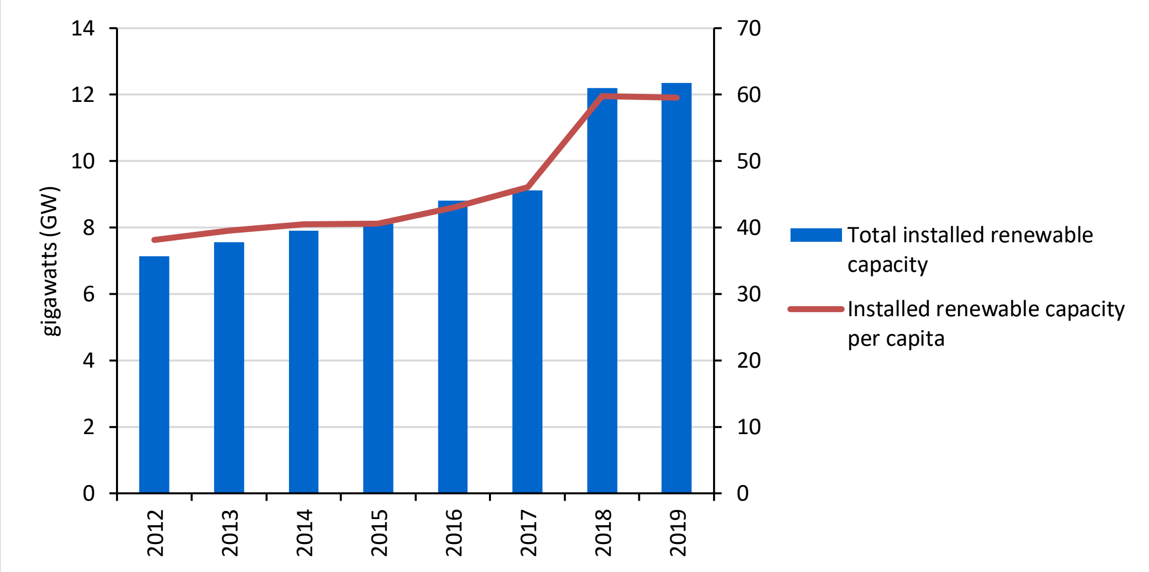

Figure 3-113 Installed renewable electricity-generating capacity in Pakistan (2012-2019)[192,193]

Figure 3-113 illustrates that the amount of installed renewable electricity generation capacity has increased substantially during the last decade (i.e., 7.1 gigawatts in 2012 to 12.3 gigawatts in 2019). Pakistan aims to reduce the projected emissions by raising the renewable energy share to 50 percent by 2030 with 15 percent coming from domestic resources and 35 percent dependent on international grant financing. On the other hand, Pakistan is bestowed with a diverse and substantial amount of renewable energy resources; however, only a few such big hydroelectric projects, as well as a few wind and solar projects, have been explored yet. The main policy interventions/plans by the government of Pakistan include 1) Alternative and Renewable Energy Policy (i.e., medium-term policy) introduced in 2011; 2) Framework for Power Cogeneration 2013 Bagasse and Biomass in force since 2013; 3) Pakistan feed-in tariff for solar power in 2014; Upfront Generation Tariff for Solar PV Power Plants in 2014; and 5) Pakistan net metering policy for solar PV and wind projects introduced in 2015.

[192] UNEP. (2022). The United Nations Environment Programme. Available at: https://wesr.unep.org/downloader
[193] IRENA (2022). RENEWABLE CAPACITY STATISTICS 2022. *The International Renewable Energy Agency (IRENA)*. Available at: https://www.irena.org/IRENADocuments/Statistical_Profiles/Asia/China_Asia_RE_SP.pdf. [Accessed on April 2022]

Energy intensity

Pakistan is also endeavoring to enhance energy efficiency and conservation due to the growing energy prices, increasing demand for energy, and diminishing energy supply. More than 40 million people (out of a total population of 220 million) remain without access to power, and half of the population does not even have access to safe cooking facilities.[194] The maximum portion of Pakistan's primary energy supply comes from oil and natural gas. On the other hand, hydropower is the most important renewable energy source in the country, but wind and solar PV are progressively increasing their proportion of the market.

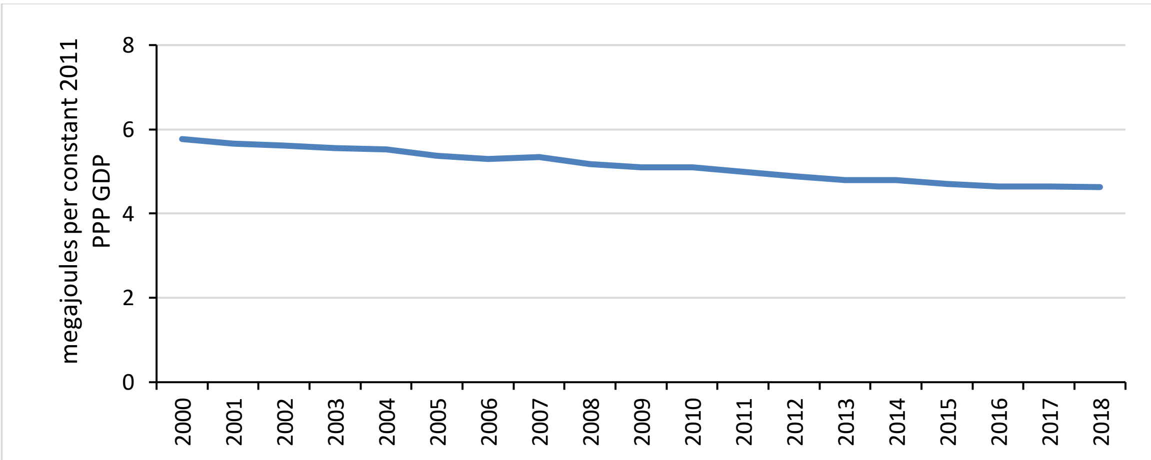

Figure 3-114 Energy intensity of Pakistan (2000-2018)[195]

As shown in **Figure 3-114**, the energy intensity of the country has been reduced steadily from 5.8 to 4.6 megajoules per constant 2011 PPP GDP from 2000 to 2018. The government's National Energy Efficiency and Conservation (NEEC) Policy 2022 was recently introduced, which focuses on energy intensity, ensures cost-effective measures, and develops market-based mechanisms to reach the country's energy efficiency objectives by 2030.[196]

[194] https://www.iea.org/countries/pakistan
[195] UNEP databank. (https://uneplive.unep.org/downloader).
[196] NEECA. (2021). National Energy Efficiency and Conservation (NEEC) Policy 2022. National Energy Efficiency and Conservation Authority | Ministry of Energy (Power division). Available at: https://neeca.gov.pk/SiteImage/Misc/files/Draft%20NEEC%20Policy%20PD%20Reviewed%20PRU%209122021.pdf

3.4.1.5 Greenhouse gas emissions

Being a party to the Paris Agreement of the United Nations Framework Convention on Climate Change (UNFCCC), Pakistan's government attaches great importance to reducing greenhouse gas emissions (GHG). Greenhouse gas emission is scientifically proven with evidence that it is the leading cause of Earth's increase in temperature, thus contributing to climate change[197,198]. Climate change is one of the triple planetary crises related to sustainability problems alongside deforestation, scarcity of drinking water, poverty, hunger and loss of biodiversity, and population growth.

Pakistan is among the top ten countries worst hit by climate change[199]. As found in most countries within the Asia Pacific region, most of Pakistan's GHG emissions come from the energy sector as the country mainly uses natural gas and furnace oil for power generation[200,201]. Furthermore, additional GHG emissions will undoubtedly follow from the expansion of agriculture, industry, and energy usage[202,203]. With the country still in its early stages of development, Pakistan's emissions are still growing due to a growing population and accompanying increased economic growth. Pakistan emitted over 400 Mt CO_2eq in 2012 as shown in **Figure 3-115**, with the energy sector contributing 46% to the overall emissions, followed closely by agriculture (41%). Pakistan's overall GHG emissions are projected to increase from about 440 Mt CO_2eq in 2011 to 4621 Mt CO_2eq in 2050.[204] Given the anticipated economic growth and corresponding growth in the energy sector, the peak of emissions in Pakistan is predicted to occur after the year 2030.

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197 Andrew, J., and Cortese, C. 2011. Accounting for climate change and the self-regulation of carbon disclosures. Accounting Forum, 35(3): 130–138. DOI: https://doi.org/10.1016/j.accfor.2011.06.006

198 Wolff, E., et al. 2014. Climate Change Evidence & Causes. National Acedemy of Sciences, 36. DOI: https://doi.org/10.17226/18730

199 Abas, N., Kalair, A., Khan, N., & Kalair, A. R. (2017). Review of GHG emissions in Pakistan compared to SAARC countries. *Renewable and Sustainable Energy Reviews*, *80*, 990–1016. https://doi.org/10.1016/j.rser.2017.04.022

200 Mir, K. A., Park, C., Purohit, P., & Kim, S. (2020). Comparative analysis of greenhouse gas emission inventory for Pakistan: Part I energy and industrial processes and product use. *Advances in Climate Change Research*, *11*(1), 40–51. https://doi.org/10.1016/j.accre.2020.05.002

201 Shan, Y., Guan, D., Zheng, H., Ou, J., Li, Y., Meng, J., Mi, Z., Liu, Z., & Zhang, Q. (2018). China CO2 emission accounts 1997–2015. *Scientific Data*, *5*, 170201. https://doi.org/10.1038/sdata.2017.201

202 IPCC. Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (Intergovernmental Panel on Climate Change, 2014).

203 Myhre, G. et al. Anthropogenic and Natural Radiative Forcing (Cambridge University, 2013).

204 Board, F. S. (2017). Recommendations of the task force on climate-related financial disclosures.

Given the significance of the UNFCCC's goals at both the national and global levels, Pakistan is committed to reducing its emissions to the greatest extent possible. However, the total mitigation potential is being hampered by financial and technical constraints. Pakistan proposes to lower emissions by up to 20% of its anticipated GHG emissions by 2030, subject to the availability of foreign subsidies to cover the complete abatement cost for the targeted 20% reduction according to Pakistan's Intended Nationally Determined Contribution (Pak-INDC).[205]

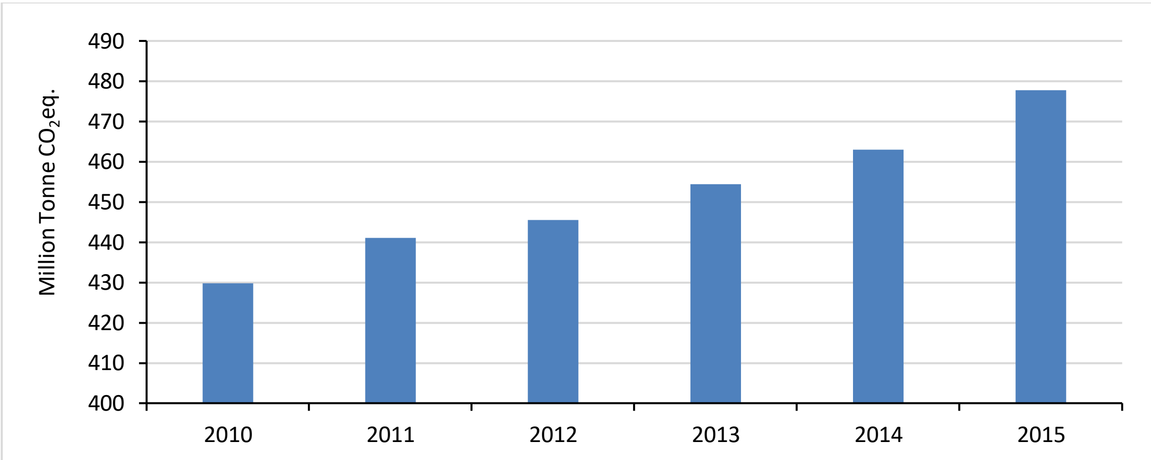

Figure 3-115 Total GHG emissions from Pakistan (2010 - 2015).

<u>Greenhouse gas intensity (2010 - 2015)</u>

As a signatory to the Paris Agreement of the United Nations Framework Convention on Climate Change (UNFCCC), the Pakistani government has done its part to assist global efforts to address climate change. The focus of the Pakistani government's climate initiatives in the coming decade will be determined by present climate-related vulnerabilities, to reduce poverty and guarantee economic stability. As a result, Pakistan plans to establish a cumulative aggressive conditional objective of reducing predicted emissions by 50% by 2030.[206] Pakistan

[205] PAKISTAN'S INTENDED NATIONALLY DETERMINED CONTRIBUTION (PAK-INDC). (n.d.). https://www4.unfccc.int/sites/submissions/INDC/Published%20Documents/Pakistan/1/Pak-INDC.pdf
[206] *THE NATIONAL CLIMATE CHANGE CONTEXT NATIONAL VISION FOR CLIMATE ACTION 12*. (n.d.). https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Pakistan%20First/Pakistan%20Updated%20NDC%202021.pdf

wants to reach 60 percent renewable energy and 30 percent electric cars by 2030, as well as a full prohibition on imported coal, to meet the objective.

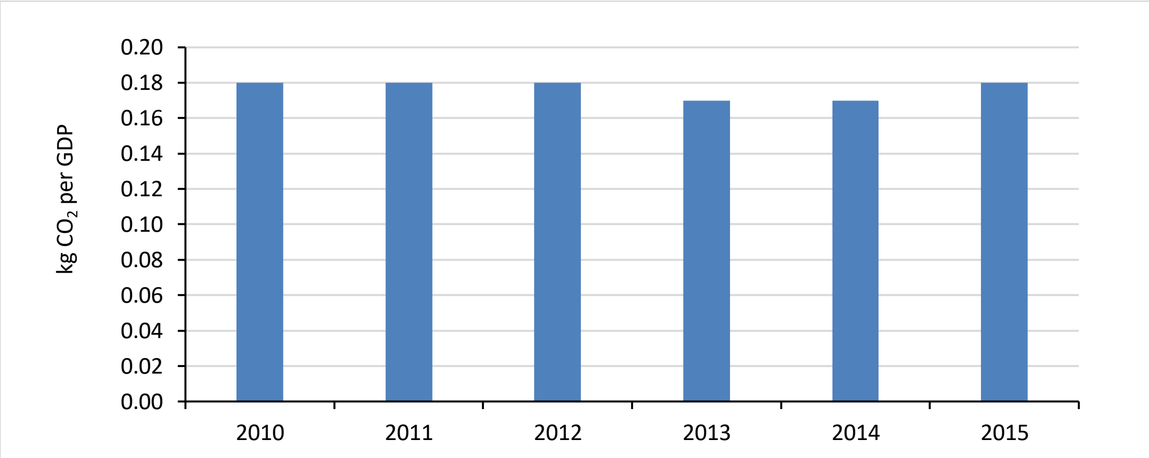

Figure 3-116 GHG intensity in Pakistan (2010 - 2015)

Population, gross domestic product (GDP), and energy systems are the main drivers of GHG emission and intensity. While GHG intensity has remained relatively consistent between 2013 and 2014, as indicated in **Figure 3-116**, there was a minor drop of roughly 5.5 percent between 2013 and 2014. Pakistan's proportion of total energy consumption from fossil fuels has increased from under 59 percent in 2000 to about 62 percent in 2015.[207] There is a target of decreasing predicted GHG emissions and intensity by 20% by 2030, subject to financial support in the region of USD 40 billion to cover the expenses of meeting this goal.[208] The State Bank of Pakistan's Renewable Energy Financing Scheme is available for projects ranging from 1 to 50 MW, to increase the percentage of renewable energy in Pakistan's energy mix.[209]

Greenhouse gas from major sectors

Greenhouse gas from energy use

Globally, the energy sector is known to be a major source of GHG emissions in most countries because of its high reliance on fossil fuel-based thermal power generation.[210] The energy

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[207] WB-WDI – World Bank World Development Indicators (The World Bank, 2019).
[208] The Government of Pakistan. (2015). Pakistan's Intended Nationally Determined Contribution (PAK-INDC).
[209] State Bank of Pakistan. (2016). Revised SBP Financing Scheme for Renewable Energy
[210] Weisser, D. (2007). A guide to life-cycle greenhouse gas (GHG) emissions from electric supply technologies. *Energy*, *32*(9), 1543-1559.

sector is one of the major contributors to GHGs in Pakistan as well. Emissions from energy generation and transportation mainly drive the emissions from the energy sector. Natural gas and oil were the dominant contributors to GHG emissions from the power sector in Pakistan till very recently. The overall GHG emissions from the energy sector (electricity generation and transportation) have been increasing steadily as shown in **Figure 3-117** and **Figure 3-118**.

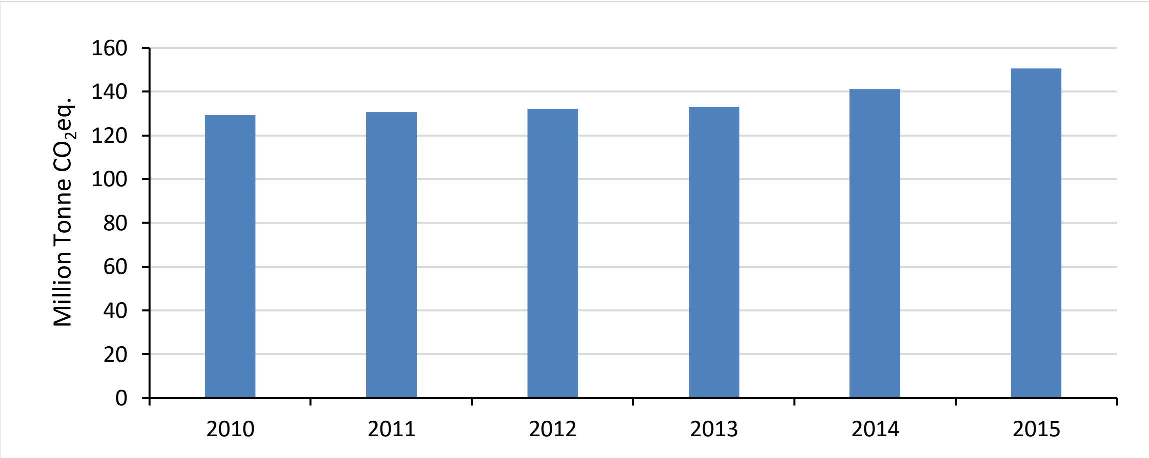


Figure 3-117 GHG emissions from the energy sector (2010 - 2015)

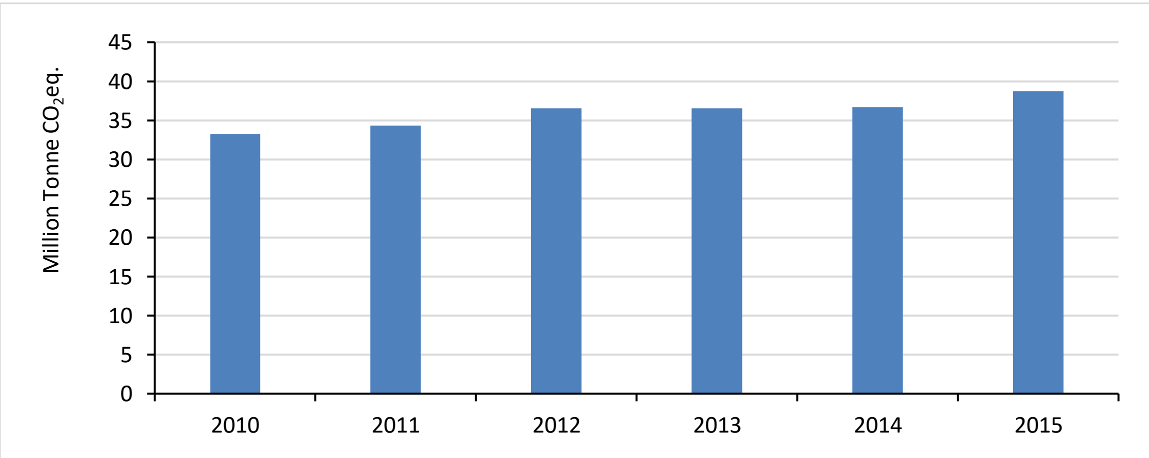


Figure 3-118 GHG from transportation (2010 - 2015)

<u>**Greenhouse gas from agriculture**</u>

Agriculture is the primary source of income in Pakistan as the country is predominantly an agrarian country.[205] Agriculture is one of the major contributors to GHG emissions in the economy as a result of its expansion to fulfill nutritional demands. From 1994 to 2015, agricultural emissions in Pakistan increased by 143.8 percent, from 71.6 to 174.6 Mt CO_2eq, a 21-year rise of 143.8 percent.[211] **Figure 3-119** depicts the increment. This increase reflects Pakistan's growing agricultural activities. According to recent national GHG estimates, agriculture is the second-largest contributor after energy. Agricultural emissions account for around 38% of overall emissions in 2015, according to these calculations.[212]

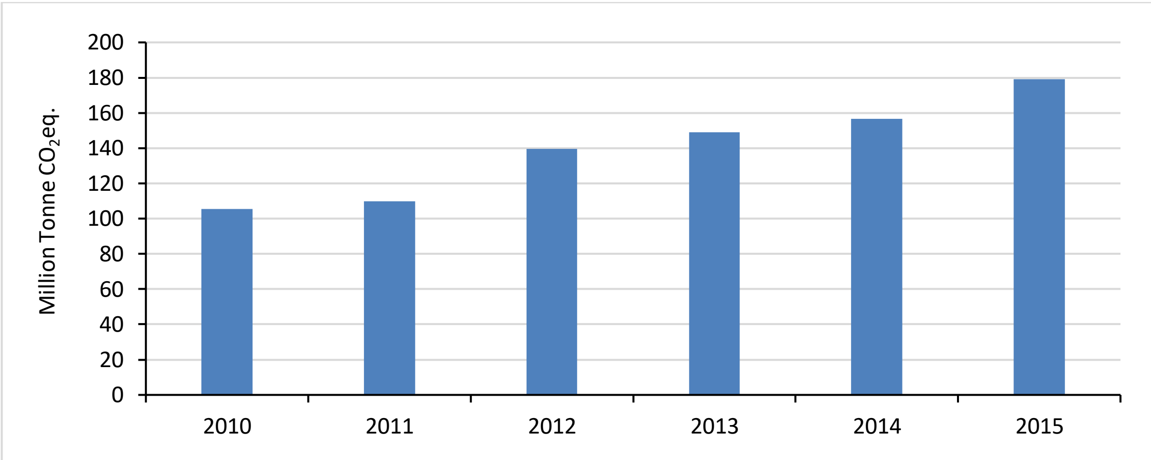


Figure 3-119 GHG emissions from Pakistan's agricultural sector (2010 – 2015)

The growing use of agricultural inputs (e.g., organic/synthetic fertilizer, crop residue burning and mixing, etc.) to boost per unit agricultural productivity, which results in greater emissions, is the cause behind this. Improved technology, rising food demand, and market competitiveness have all contributed to commercial agriculture's displacement of traditional agriculture over the last 21 years (1994–2015). This has also contributed to an increase in the rate of emissions from agricultural soils.[213] Due to a lack of awareness and an insufficient calculation of agricultural emissions in Pakistan, attempts to reduce these emissions have yet to be implemented.

[211] Ijaz, M., & Goheer, M. A. (2020). Emission profile of Pakistan's agriculture: past trends and future projections. *Environment, Development and Sustainability*. https://doi.org/10.1007/s10668-020-00645-w
[212] Mir, K. A., & Ijaz, M. (2016). *Greenhouse gas emission inventory of Pakistan for the year 2011–12*. GCISC-RR-19, Global Change Impact Studies Centre (GCISC), MINISTRY CLIM CHANGE, ISLAMABAD. ISBN: 978-969-9395-20-8. http://www.gcisc.org.pk/GHGINVENTORY2011-2012_FINAL_GCISCRR19.pdf.
[213] Ijaz, M., & Goheer, M. A. (2020). Emission profile of Pakistan's agriculture: past trends and future projections. *Environment, Development and Sustainability*. https://doi.org/10.1007/s10668-020-00645-w

3.4.1.6 Human Development Index

The major goal of human development is to lead society towards greater mutual well-being via productive economic activities.[214] Every additional natural resource use provides support to human development. Therefore, in this section of the report, the relationship between the Human Development Index (HDI) – a measure of human development, and the growth in natural resource use is examined. HDI consists of three different domains, viz., literacy rate, life expectancy, and standard of living, while natural resource use here refers to material use. The data for direct material use, material footprint, and HDI was sourced from UNDP. The time series here covers the period from 2010 to 2017. Some Asian countries have shown a remarkable improvement in all three domains of HDI since the 1980s. However, China, India, Indonesia, Pakistan, Thailand, and Viet Nam are selected to investigate the relationship between material use and the HDI because they are found to be the most significant material users.

3.4.1.7 Material use and HDI

Figure 3-120 shows that the relationship between direct material use and HDI in Pakistan is stronger as compared to the relationship between the material footprint of consumption and HDI. Moreover, for Pakistan, the correlation between direct material use and HDI is stronger as compared to material footprint as indicated by the values of correlation coefficient "r" between direct material use and HDI, and material footprint and HDI, which were 0.9659 and 0.8623, respectively, from 2010 to 2017. The reason behind the comparatively stronger correlation between direct material consumption and HDI as compared to material footprint and HDI is that the direct material use is associated with large extraction and significant manufacturing activities, and Pakistan's economy is highly dependent on minerals extraction and agro-based industry which generate wealth for the country and create a large share of employment in the economy.

[214] https://hdr.undp.org/en/content/human-development-index-hdi

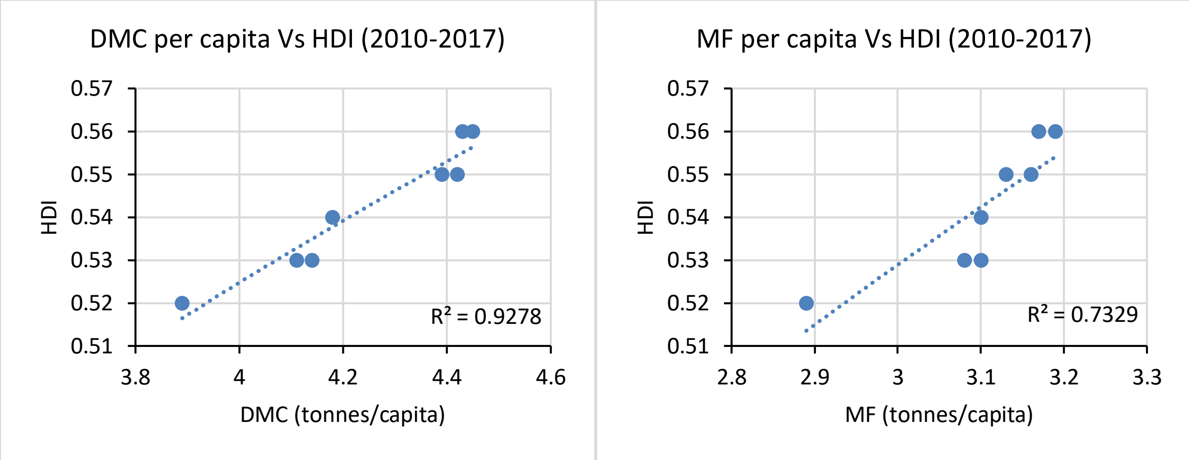


Figure 3-120 The relationship between the human development index (HDI) versus material use (DMC per capita), and material footprint (MF per capita) for Pakistan (2010-2017)

3.4.1.8 Economic Growth

The total monetary or market worth of all completed products and services produced within a country's boundaries in a certain period is known as the gross domestic product (GDP). It serves as a complete assessment of a country's economic health since it is a wide measure of entire domestic production. It is the most commonly used indicator for measuring economic growth and it is a broader estimate of the overall domestic production of any region. In this section, GDP is used as a complementary indicator to show how overall production activities provide a different perspective on domestic material consumption and material footprint in concerned six Asian countries.

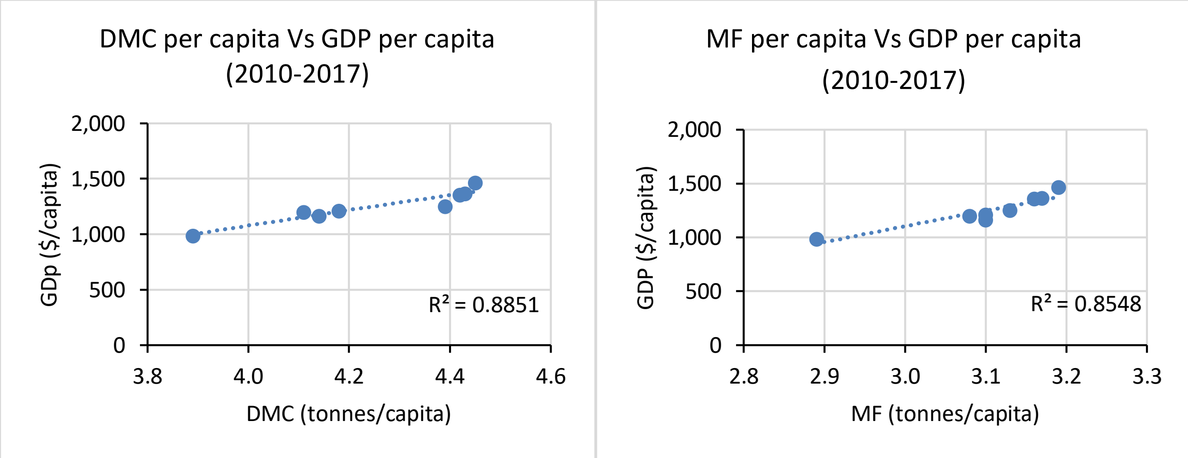


Figure 3-121 The relationship between the GDP per capita versus, material use (DMC per capita), and material footprint (MF per capita) Pakistan (2010, 2017)

In **Figure 3-121**, Pakistan's DMC per capita (tonnes/capita) and material footprint per capita (tonnes/capita) is plotted against GDP per capita for 2010 and 2017. It can be seen that the DMC per capita has a positive and comparatively stronger relationship with GDP per capita than material footprint per capita. Moreover, for Pakistan, the correlation between direct material use and GDP is stronger as compared to material footprint and GDP as the value of correlation coefficient "r" between direct material use and GDP, and material footprint and GDP was 0.9408 and 0.9295, respectively, from 2010 to 2017. It shows that as more and more material is used in the production system, the countries attain higher economic growth. However, it is unfavorable for the decoupling of material use from economic development. To achieve decoupling, Pakistan has to adopt more advanced and material-efficient production systems.

3.4.1.9 Physical trade balance

Globalization is increasing the interdependence of countries for goods; hence embodied/ indirect natural resources of traded products are growing significantly. Over the last decades, many countries have changed from being net exporters to importers; but on the other hand, a few countries have changed from being importers to exporters. This can cause a destabilizing effect from fewer exporters' supply to rising demand in the world economy[215]. The physical trade balance is represented in three sectors: the agricultural sector, food sector, and construction sector from six selected countries in the Asia Pacific region.

Agricultural sector

Pakistan is an agricultural exporter (**Figure 3-122**). The crop comprised the largest share in the agricultural sector at more than 97% of exported agricultural products; the remaining were crop residues (2%) and grazed biomass and fodder crops (1%). The major crops are cotton, rice, sugarcane, fruits, and vegetables. The deficit of the agricultural sector remained around a 3% yearly increase since 2013. Only in 2012, did that deficit plummet by 124%. This was caused by a loss of over a million acres of crops and agricultural lands from the 2011 Sindh floods and the 2012 Pakistan floods. **Figure 3-123** shows that the per capita physical trade balance stayed relatively constant at around -0.01 tonnes per capita over the period 2013 to 2017.

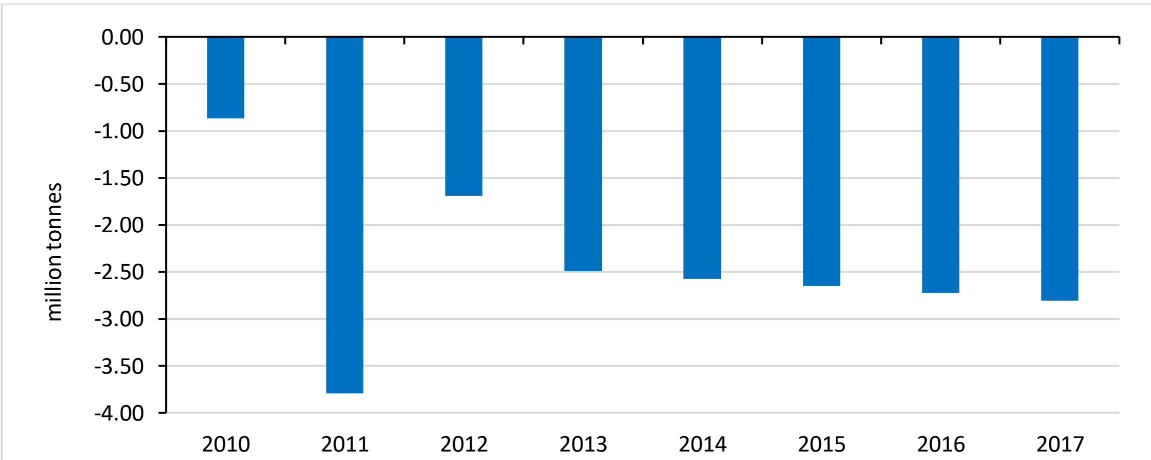


Figure 3-122 Physical trade balance by agricultural sector in Pakistan, 2010 to 2017

[215] UNEP (2020). *Sustainable Trade in Resources Global Material Flows, Circularity and Trade*. UNEP. https://wedocs.unep.org/bitstream/handle/20.500.11822/34344/STR.pdf

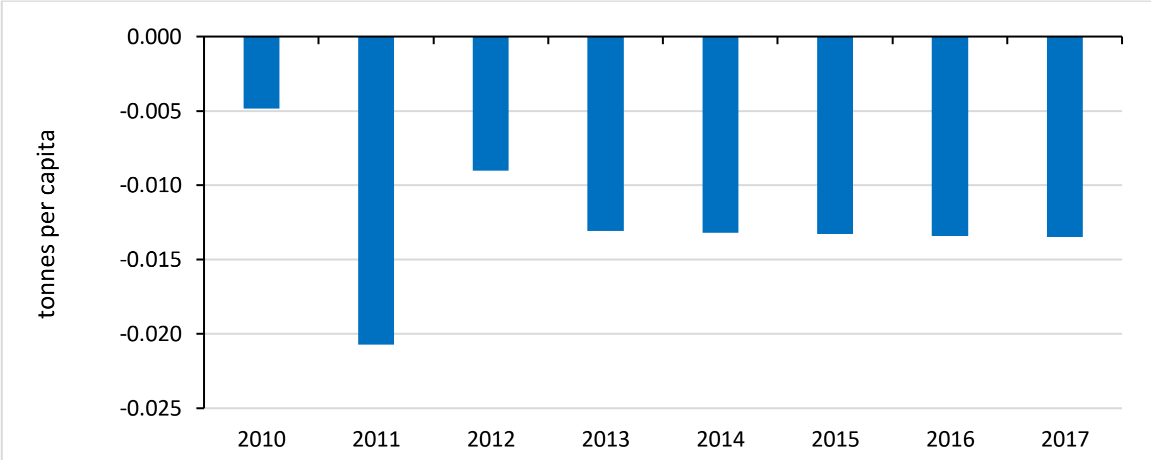


Figure 3-123 Physical trade balance per capita by agricultural sector in Pakistan, 2010 to 2017

<u>Food sector</u>

The crop (for food) and wild catch & harvest sub-categories are considered under the food sector. In 2011, the exported crops dramatically increased due to the government termination in export ban on wheat grain. [216] Due to the decline of exported crops from adverse climatic situations (i.e., the 2011 Sindh floods and the 2012 Pakistan floods), the deficit of the food sector plunged by 125% in 2012[44,217]. However, after 2013 the growth rate entered a relatively stable state (**Figure 3-124**). Pakistan's per capita trade in the food sector in 2017 was -0.013 tonnes per capita, which almost tripled between 2010 and 2013 (**Figure 3-125**).

[216] Bellmann,C. and Hepburn,J.(2017). The Decline of Commodity Prices and Global Agricultural Trade Negotiations: A Game Changer? *International Development Policy | Revue internationale de politique de développement*, 8.1 | 2017, https://doi.org/10.4000/poldev.2384

[217] FAO (2011). *Executive Brief Pakistan Floods 2011* .FAO . https//:www.fao.org/fileadmin/user_upload/emergencies/docs/12.12.11_Pakistan_Floods_FAOEB.pdf

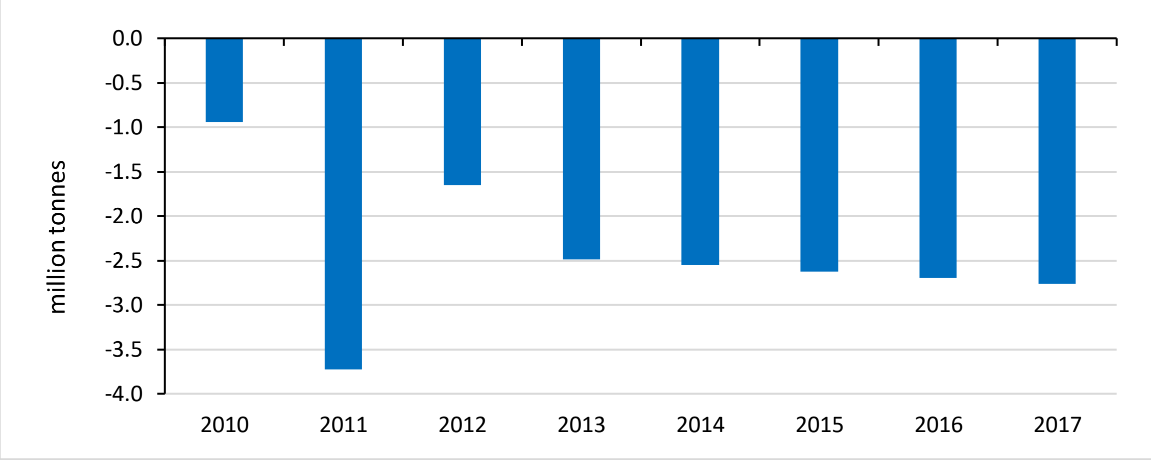


Figure 3-124 Physical trade balance by food sector in Pakistan, 2010 to 2017

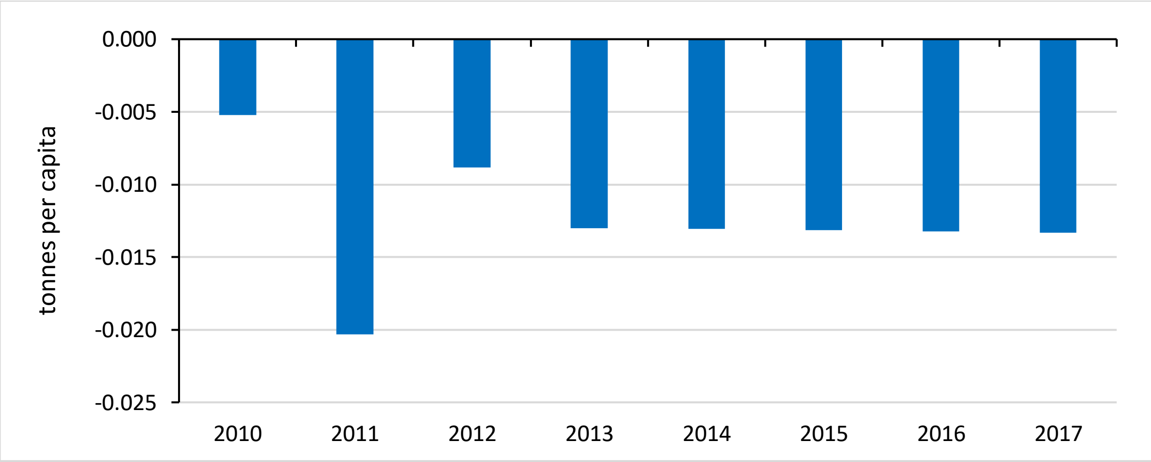


Figure 3-125 Physical trade balance per capita by food sector in Pakistan, 2010 to 2017

Construction sector

The non-metallic minerals of construction dominant sub-categories are considered in the construction sector. Due to the large decrease in exports, Pakistan's deficit in the construction sector decreased by 39% in 2011 caused of no limestone stabilization during the maintenance of the house and buildings damaged from floods, (**Figure 3-126**).[218] After 2015, the deficit

[218] Shelter Centre (2014). Evaluation of One Room Shelter Programme for the 2011 floods response in South Sindh, Pakistan, Shelter Centre for IOM Mission in Pakistan. https://www.iom.int/sites/g/files/tmzbdl486/files/country/docs/pakistan/IOM-Pakistan-Evaluation-of-One-Room-Shelter-Program-for-2011-Flood-Response.pdf

faced a slow decline. PTB per capita was -0.06 tonnes per capita in 2017 and it remained constant at around 5% from 2011 to 2015 (**Figure 3-127**).

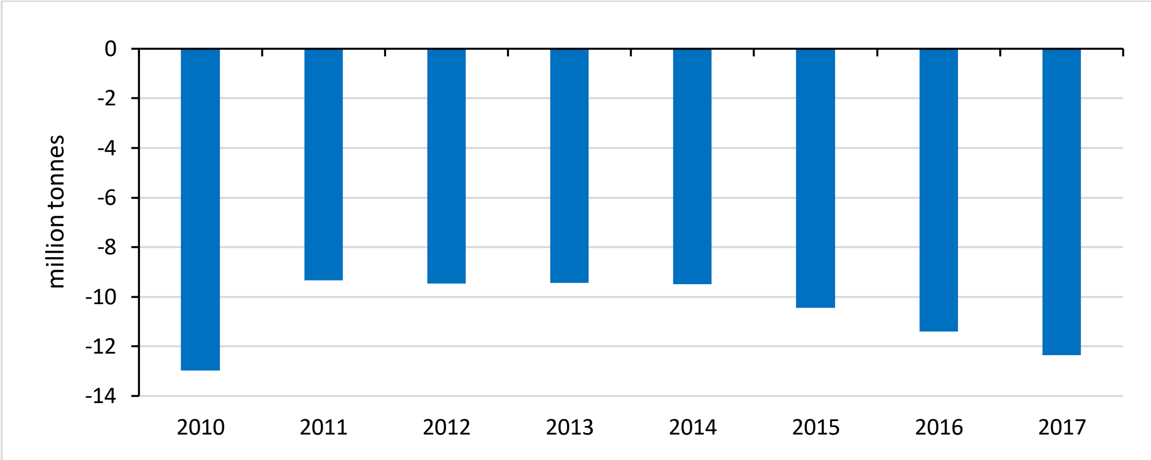


Figure 3-126 Physical trade balance by construction sector in Pakistan, 2010 to 2017

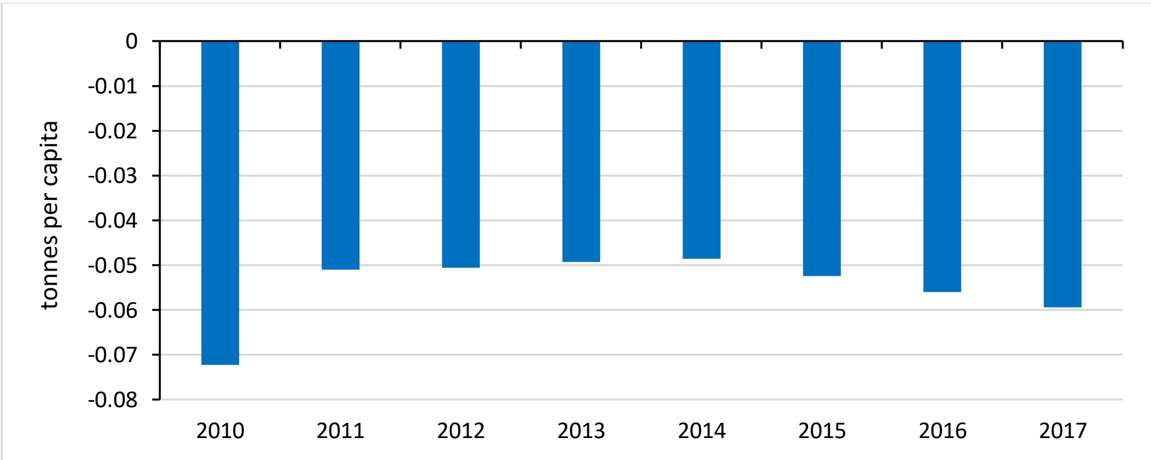


Figure 3-127 Physical trade balance per capita by construction sector in Pakistan, 2010 to 2017

3.4.2 Consolidated discussion

In Pakistan, the increase in population and economic growth are influencing the use of natural resources. Consequently, GHG emissions and material use are increasing. On the other hand, the reduction in land use in the agricultural sector was observed due to natural disasters such as droughts. However, renewable energy share is increasing over time. Currently, the government is putting its action plan for population management, a more favorable trade balance, and environmental protection measures into effect. A summary of SCP indicators and issues considering the DPSIR framework for Pakistan is presented in **Table 3-6**.

Table 3-6 A summary of SCP indicators and issues considering the DPSIR framework for Pakistan.

Drivers	State/ impact	Responses
- Increasing population (179 million in 2010 to 208 million in 2017) - Increased economic activity (USD 987 per capita in 2010 to USD 1465 per capita in 2017 and total GDP from USD 177 billion in 2010 to USD 305 billion in 2017)	- Domestic material consumption increased from 0.7 billion tonnes in 2010 to around 0.9 billion in 2017 - Alternative and renewable energy sources' installed capacity in the power sector has already increased from 0.2 percent in 2013 to 5.2 percent in 2018. - The agriculture sector is the major contributor to land use and water use • Land use in the agriculture sector was decreased from 10.96 million hectares that were by 6.72 million hectares in 2018 • Water use in the agriculture sector was decreased from 26.32 billion cubic meters to 20.26 billion cubic meters in 2018	The major policy interventions or responses include: - Alternative and Renewable Energy Policy (i.e., medium-term policy) introduced in 2011; - Framework for Power Cogeneration 2013 Bagasse and Biomass in force since 2013; - Pakistan feed-in tariff for solar power in 2014; - Upfront Generation Tariff for Solar PV Power Plants in 2014; - Pakistan's net metering policy for solar PV and wind projects introduced in 2015 - National Energy Efficiency and Conservation (NEEC) Policy was introduced in 2022 to enhance energy intensity. The fundamental plan for

Drivers	State/ impact	Responses
	- The physical trade balance is negative for all the considered sectors - The overall GHG emissions are projected to increase from about 440 Mt CO_2eq in 2011 to 4621 Mt CO_2eq in 2050.	establishing a Sound Material Cycle Society also known as Fundamental Law was implemented in 2000. - Punjab Irrigated-Agriculture Productivity Improvement Project was in effect since 2008 to improve water use efficiency in the agriculture sector.

3.5 Thailand

- The agricultural sector is the biggest contributor to land use in Thailand which has increased over time.
- Overall, resource use (e.g., renewable energy and material use) and GHG emissions are increasing over time.
- However, the reduced availability of water is causing a reduction in water use in the food sector.
- Thailand is implementing different measures for family planning, environmental issues, and trade balance.

Thailand is situated in the heart of Southeast Asia's mainland. It is the world's 50th largest country, with a total land area of 513,120 km^2. Thailand's land border stretches for 4,863 kilometers. Myanmar and the Andaman Sea are to the west, Cambodia and Laos are to the east, Myanmar and Laos are to the north, and Malaysia and the Gulf of Thailand are to the south.[219] Thailand's population grew from 67 million in 2010 to about 70 million in 2017. (see **Figure 3-128**). As of 2022, the country's population was expanding at a much faster rate, and it was rated as the world's 22nd most populous country.[220] The country, on the other hand, claims that a government-funded family planning program has increased awareness and resulted in a substantial drop in birth rates. In 1960, population growth was at its peak, with numbers of over 3.1 percent, but it has since decreased to below 0.34 percent. [221]

[219] https://www.tourismthailand.org/Articles/plan-your-trip-history-and-geography-geology
[220] https://www.worldometers.info/world-population/thailand-population/
[221] https://worldpopulationreview.com/countries/thailand-population

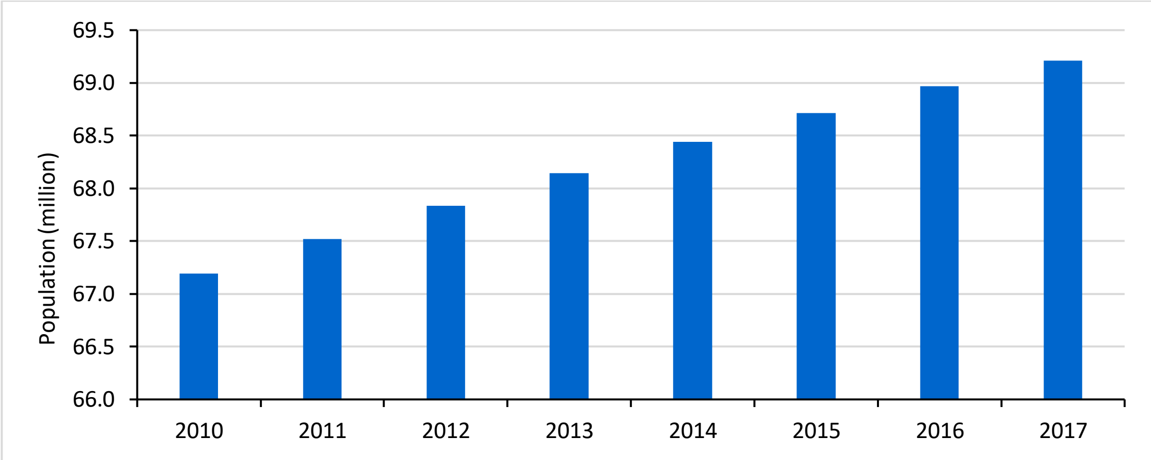


Figure 3-128 Population of Thailand (2010-2017)

In 2017, the world economy expanded by an estimated 3.0%, up from 2.4 percent in 2016. Thailand's economy grew by 3.9 percent in 2017, the fastest since 2012. This was fueled by rapid export growth, which was boosted by solid global growth.[222] For example, per capita GDP went from USD 5080 to USD 6600 in 2017 while overall GDP climbed from USD 341 billion to USD 456 billion. The GDP per capita and GDP (total) for Thailand are presented in **Figure 3-129**.

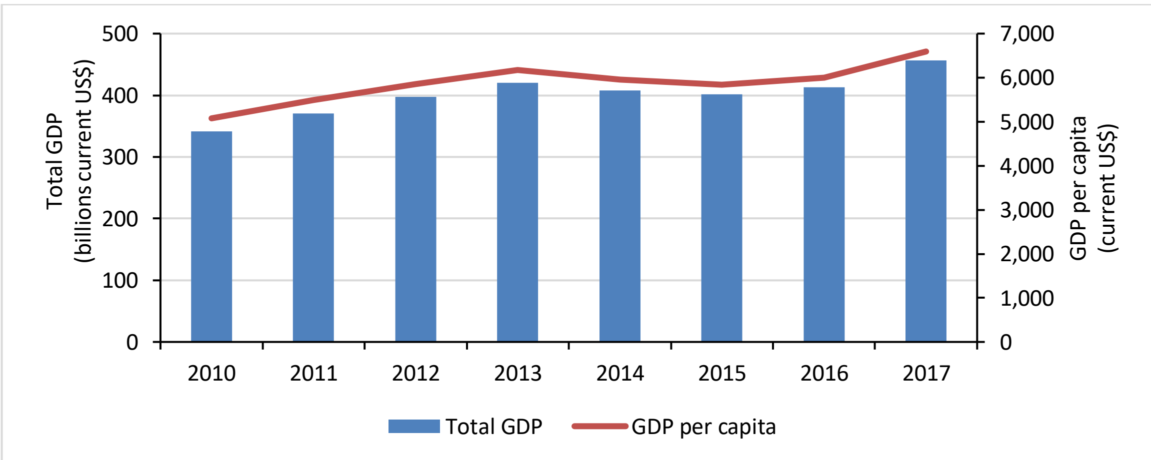


Figure 3-129 Gross domestic product (GDP) of Thailand (2010-2017)

In 2021, the economic activities in Thailand's severely slowed down due to the major surge in COVID-19 cases. However, the Thai economy's recovery is now underway. In 2021, the

[222] https://www.worldbank.org/en/country/thailand/publication/thailand-economic-monitor-april-2018-beyond-the-innovation-paradox

economic growth in the country was around 1% which falls within the range of the previous forecast of 0.7-1.2%. Despite the recent reopening of international borders, the estimate reflected the continued weakness in private consumption owing to COVID19 and the expectation that tourist numbers will remain minimal through the end of 2021. Exports of goods, on the other hand, have fueled growth in the face of strong global demand, and investment is likely to climb. Cash transfers, public health efforts, economic recovery programs, and other types of financial assistance have all aided in bolstering private demand while also sustaining consumption among disadvantaged households and mitigating the crisis' impact on poverty.[223] **Figure 3-130** shows the detailed analysis of Thailand's profile through DPSIR Framework.

[223] https://documents1.worldbank.org/curated/en/099505112112129099/pdf/P1774810eff81c0030b22f0874a695a491d.pdf

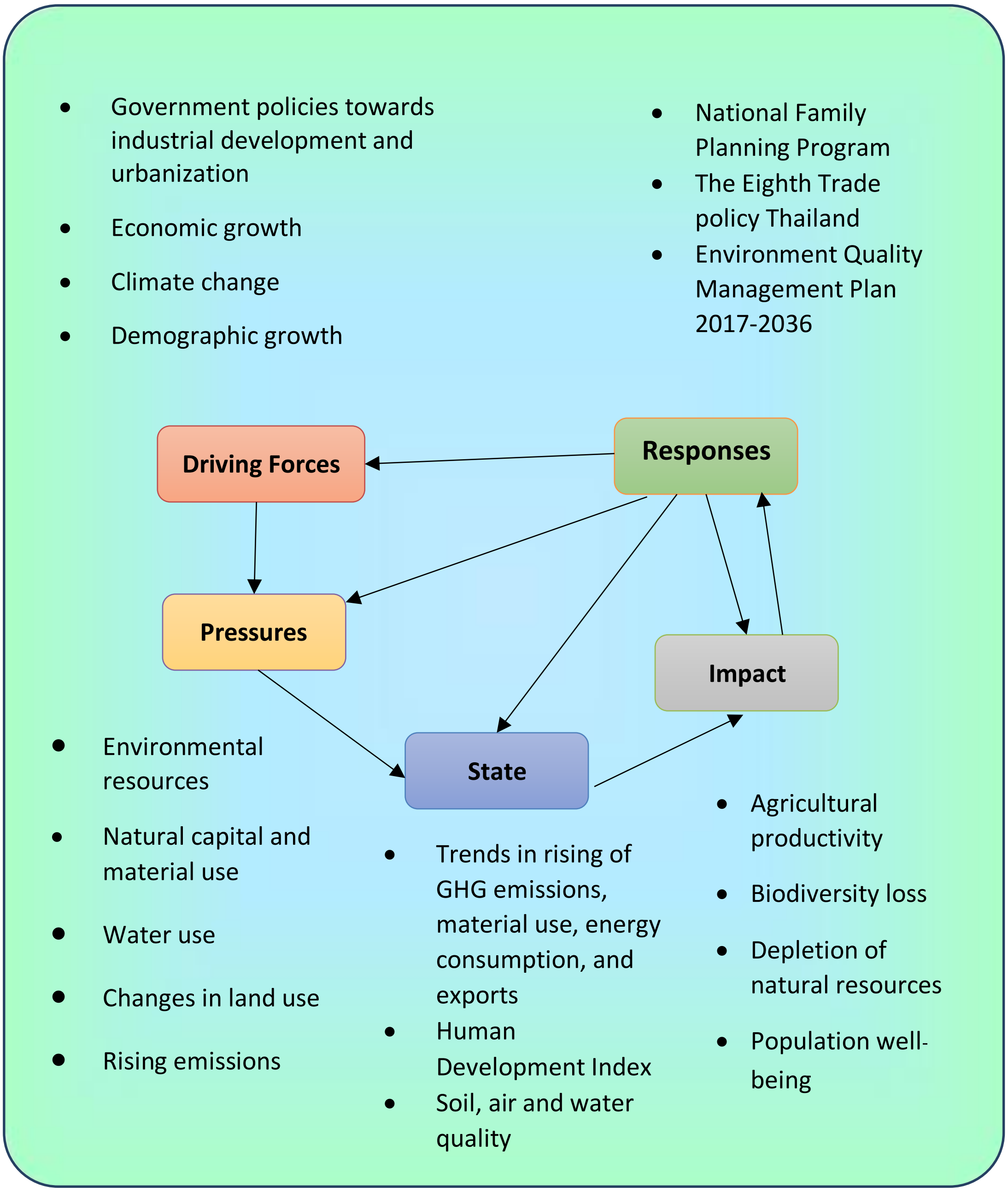


Figure 3-130 DPSIR framework of Thailand

3.5.1 Indicators

3.5.1.1 Water Use

Water use in the agriculture sector deals with the water use by food crops (wheat, maize, cereals, etc.), oil, fiber, non-perennial, spices, aromatic, drug and pharmaceutical, and crop beverage crops, perennial crops, plant propagation, and water use in livestock farming[224]. The water use footprint of the agriculture sector of Thailand was increasing from 2010 to 2018. In 2018, the total water use in Thailand was 6.40 billion cubic meters per year. Overall, it decreased at the rate of 0.025 billion cubic meters per year and in terms of percentage, it increased by almost 9 percent from 2010 to 2018. The decrease in the water use footprint of the agriculture sector is due to the change in land use in the agriculture sector. The time series of water use footprint of the agriculture sector of Thailand from 2010 to 2018 is shown in **Figure 3-131.**

Water footprint of food sector

Water use in the food sector deals with the water used by processing, preserving, and manufacturing meat and fish-based products, cereal-based products, food crop products, mixed food and feed, cocoa, fiber-based products, chocolate and sugar confectionery, vegetable, and animal oils and fats, and Manufacture of dairy products, alcoholic and other beverages, tobacco products[225]. The water use footprint of the food sector of Thailand was showing decreasing trends. In 2010 the water use of the food sector in Thailand was 0.2 billion cubic meters. Overall, it was increasing at the rate of 0.008 billion cubic meters per year and in terms of percentage, it increased by almost 38 percent from 2010 to 2018. The increase in the water use footprint of the food sector is probably due to the expansion of food production and processing industry. The time series of water use footprint of the food sector of Thailand from 2010 to 2018 is shown in **Figure 3-131**.

Water footprint of construction sector

Water use in the construction sector is defined as the water use in the construction of all buildings, roads and railways, utilities, and other civil engineering activities. The water use footprint of the construction sector of Thailand was decreasing, it decreased at the rate of 0.006 billion cubic meters per year and in terms of percentage, it decreased by almost 21 percent from 2010 to 2018. In 2018, the total water use in Thailand was 0.22 billion cubic meters. The water use footprint of the construction sector of Thailand was decreasing even

[224] SCP-HAT (http://scp-hat.lifecycleinitiative.org/module-2-scp-hotspots/)
[225] SCP-HAT (http://scp-hat.lifecycleinitiative.org/module-2-scp-hotspots/)

though the drivers such as population, economy, etc., were increasing. It is due to the decoupling efforts of the policymakers. The time series of water use footprint of the construction sector of Thailand from 2010 to 2018 is shown in **Figure 3-131**.

Water footprint of tourism sector

The water use footprint of the tourism sector of Thailand was decreasing, with the rate of 0.031 billion cubic meters per year, and in terms of percentage, it decreased by almost 20 percent from 2010 to 2018. In 2018, the total water use in Thailand was 1.15 billion cubic meters per year. From 2015 and 2016 it decreased sharply however the tourism activities increased in Thailand at the same time, which is evidence of decoupling. The time series of water use in the tourism sector of Thailand from 2010 to 2018 is shown in **Figure 3-131**.

Water use footprint of transport sector

Water use in the transport sector is defined as the water use by land transport, water transport, air transport, transport via pipeline, warehousing, and support activities for transportation. The water use footprint of the transport sector of Thailand was decreasing, with the rate of 0.0047 billion cubic meters per year, and in terms of percentage, it decreased by almost 48 percent from 2010 to 2018. In 2018, the total water use in Thailand was 0.07 billion cubic meters per year. The water use in the transport sector of Thailand is decreasing even though the drivers such as population, economy, etc. are increasing. It is due to the decoupling efforts of the policymakers. The time series of water use footprint of the transport sector of Thailand from 2010 to 2018 is shown in **Figure 3-131**.

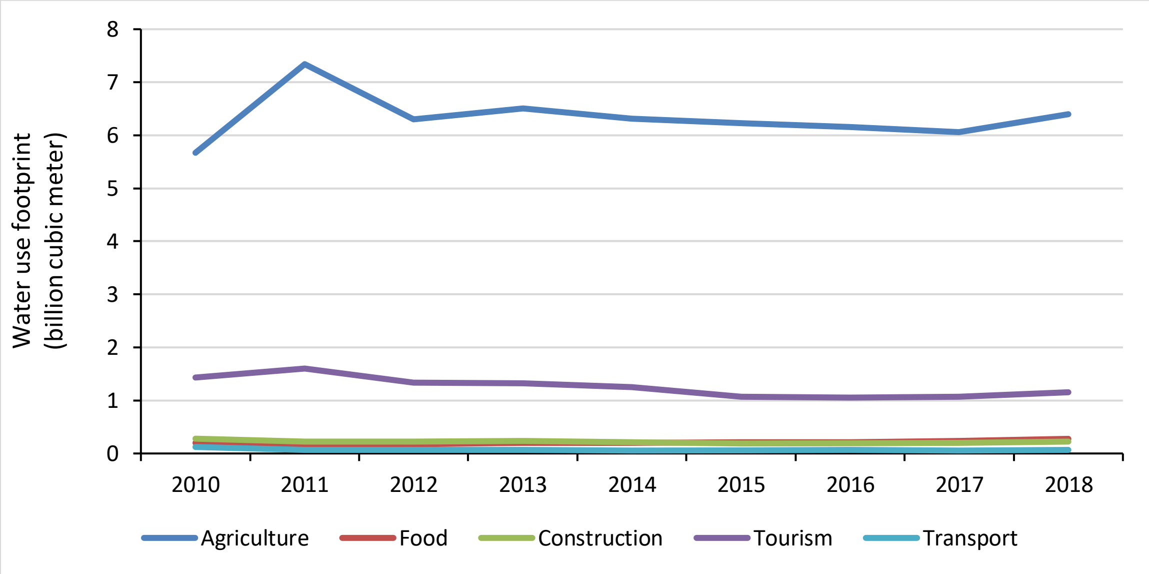


Figure 3-131 Water use footprint in five different sectors of Thailand

3.5.1.2 Land use

In the recent history of mankind, human development has increased at an ever-faster rate. As a result of this, unprecedented changes in land use have been noticed. The change in different land-use types is driven by growth in population, GDP, food requirements, etc. (Zhao et al., 2006). To analyze the hotspot sectors and the regions, the SCP Hotspots Analysis Tool (SCP-HAT) provides the land use footprint of multiple sectors. This section is focusing water use in five different sectors (viz., agriculture, food, tourism, construction, and transportation). In this report, the hotel and restaurants sector is used as a proxy for tourism.

Land footprint in major sectors

Land footprint in agriculture sector

Land use footprint of the agriculture sector in Thailand was showing an increasing trend from 1990 to 2018. In 1990 the land use of the agriculture sector in Thailand was 2.38 million hectares which increased by 2.23 million hectares by the end of 2018. The highest land use in the agriculture sector was noticed in 1997 which was 12.85 million hectares. Overall, it increased at the rate of 0.094 million hectares per year and in terms of percentage, it increased by almost 94 percent from 1990 to 2018. The forest cover in Thailand was decreased and forest cover was replaced by agricultural land[226] which can be the main reason for the increase in land use footprint of the agriculture sector in Thailand. The time series of land use in the agriculture sector of Thailand from 1990 to 2018 is shown in **Figure 3-132**.

Land footprint in food sector

Land use footprint of the food sector of Thailand was showing slight increase trends from 1990 to 2018. In 1990 the land use of the food sector in Thailand was 13.72 million hectares which increased by 9.001 million hectares by the end of 2018. The highest land use footprint of the food sector was noticed in 1996 which was 26.34 million hectares. Overall, it was increasing at the rate of 0.266 million hectares per year and in terms of percentage, it increased by almost 14 percent from 1990 to 2018. The increase in land use footprint of the food sector also links with the agriculture sector which is why the land use footprint of the food sector of Thailand also follows almost the same trend as agriculture does. The time series of land use in the food sector of Thailand land from 1990 to 2018 is shown in **Figure 3-132**.

Land use footprint in construction sector

Land use footprint of the construction sector of Thailand was showing a decrease, especially in the last two decades. In 1990 the land use of the construction sector in Thailand was 1.37 million hectares which decreased by 1.0 million hectares by the end of 2018. The highest land use footprint of the construction sector was noticed in 1996 that was 1.92 million hectares. Overall, it was decreasing at the rate of 0.0443 million hectares per year and in terms of percentage, it decreased by almost 73 percent from 1990 to 2018. The decrease in land use footprint of the construction sector is due to the slowdown in the population increase. The time series of land use footprint of the construction sector of Thailand land from 1990 to 2018 is shown in **Figure 3-132**.

Land use footprint in transport sector

Land use footprint of the transport sector in Thailand decreased from 1990 to 2018. In 1990 the land use of the transport sector in Thailand was 0.28 million hectares that were decreased

[226] O Nabangchang-Srisawalak. Land tenure data in Thailand. UN Food and Agriculture Organization, 2006. Accessed April 2016.

by 0.04 million hectares by the end of 2018. The highest land use footprint of the transport sector was noticed in 1996 which was 0.33 million hectares. Overall, it decreased with the rate of 0.0022 million hectares per year and in terms of percentage, it decreased by almost 12 percent from 1990 to 2018. The decrease in land use in the transport sector is probably due to the decoupling efforts of the policymakers or the dependence of the country on foreign resources for the transport sector. The time series of land use footprint of the transport sector of Thailand from 1990 to 2018 is shown in **Figure 3-132**.

Land use footprint in tourism sector

Land use footprint of the tourism sector in Thailand was showing a significant decreasing trend from 2005 onwards. In 1990 the land use footprint of the tourism sector in Thailand was 1.34 million hectares which decreased by 0.01 million hectares by the end of 2018. The highest land use footprint of the tourism sector was noticed in 2001 which was 1.70 million hectares. Overall, it was decreasing at the rate of 0.0129 million hectares per year and in terms of percentage, it decreased by almost 7 percent from 1990 to 2018. The time series of land use footprint of the tourism sector of Thailand land from 1990 to 2018 is shown in **Figure 3-132**.

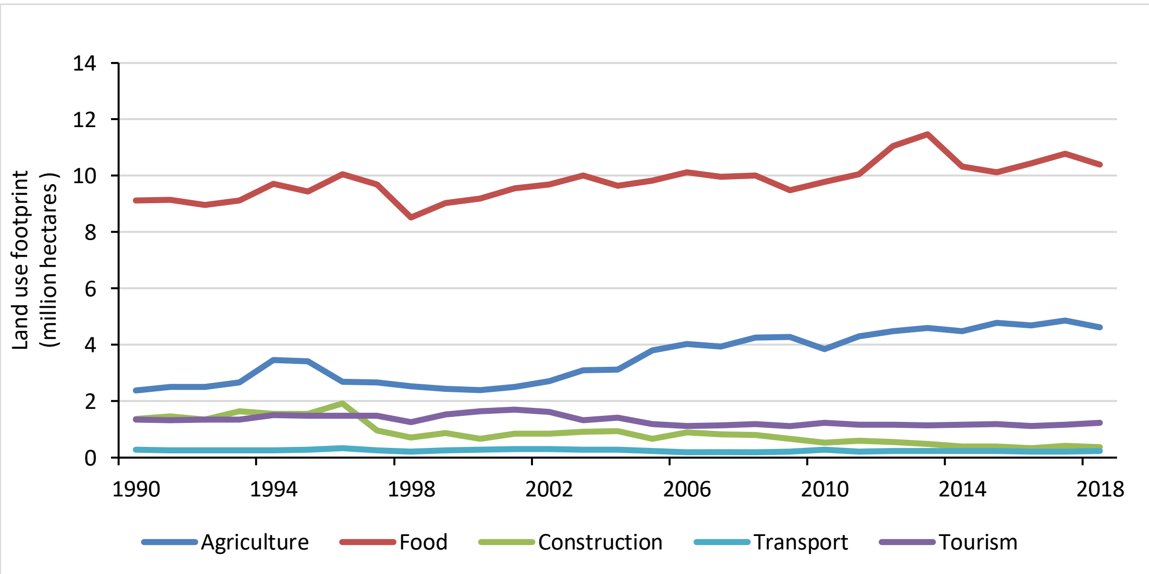


Figure 3-132 Land use of five different sectors of Thailand

3.5.1.3 Material use

Material use by major sectors

Private spending growth in Thailand improved modestly from 3.1 percent in 2016 to 3.2 percent in 2017, while consumer confidence increased somewhat but remained below 2011 high levels. Private consumption of natural resources accounted for nearly half of GDP in 2017, hence the minor increase in consumption growth contributed to nearly half of overall economic growth. [227] **Figure 3-133** shows the sector-wise material consumption in Thailand.

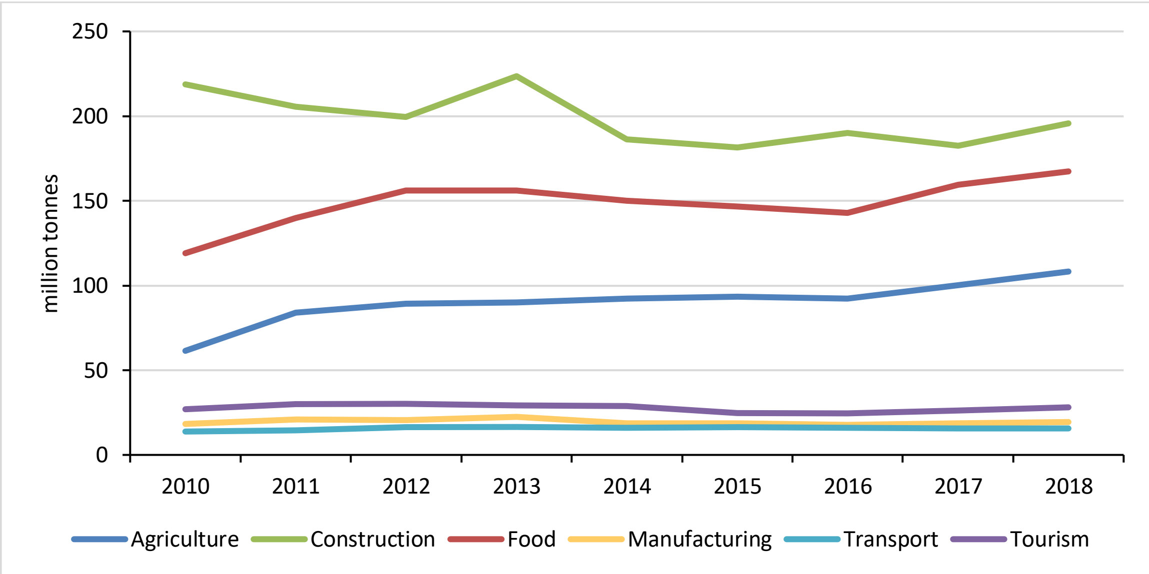


Figure 3-133 Sector-wise material footprint in Thailand (2010-2018)

It can be seen from **Figure 3-133** that the construction sector has the highest material consumption though the sector has experienced some ups and downs during the considered time series. However, the overall material consumption of the construction sector decreased in 2018 as compared to 2011. The food sector (the second most significant regarding material consumption) in the country experienced a continuous increase in its material consumption. The third-largest sector is the agriculture sector. An increase in material consumption of the country's agriculture sector was noted at the beginning of the previous decade but it almost

[227] World Bank. 2018. Thailand Economic Monitor: Beyond the Innovation Paradox. The World Bank Group. [Last accessed: 14.01.2022], [Available at: https://documents1.worldbank.org/curated/en/991791530850604659/pdf/Thailand-Economic-Monitor-2018-Beyond-the-Innovation-Paradox.pdf].

remained constant later. The sectors including manufacturing, tourism, and transport are the bottom three sectors, respectively.

Paper recycling at SCG packaging

Municipal waste generation and management of it is a big challenge as it plays a role in environmental degradation. SCG's design practice is a sustainable practice made for recycling high-quality fiber paper. SCG's practice helps to solve the problems of waste generation and management. It also fulfills the growing raw materials requirements of the company through the recycling of wastepaper. Therefore, recycling the paper helps substitute the wood from virgin sources, waste management, and ecological benefits. Thus, the recycling practice was carried out by the research and development department of SCG, which innovated a process to produce high-quality fiber having an equivalent yield output to that of virgin raw material (i.e., wood).

This is also in line with the policies of promoting green products, recycling, and a circular economy. The main characteristics of the process include the collection and classification of used paper, its storage, transportation, and finally recycling it.

Papermill paper scraps discarded paper materials and discarded after consumer usage are all sources of waste papers. The SCG recycling company is recovering the used paper from the bailing station and recycling it in the packaging paper mill to produce the packaging products of the same quality as from the virgin source.

The 100% recycling of used paper substitutes the wood raw material. The 100% recycling helps to reduce wastepaper and saves the energy required for the Eucalyptus plantation. Also, eucalyptus plantation requires water; therefore, the recycling of paper results in keeping the water. As of 2016, tremendous economic benefits were obtained in substituting the fiber import of around 24.1 million Thai baht per year. Greenhouse gas saving is also another environmental benefit of this paper recycling as the number of trees being felled/processed to meet the requirements of wood for paper production is reduced (i.e.,

Paper recycling at SCG packaging
saving the trees). It also creates a job avenue for collecting and recovering the used paper from solid waste.

<u>Material footprint of consumption</u>

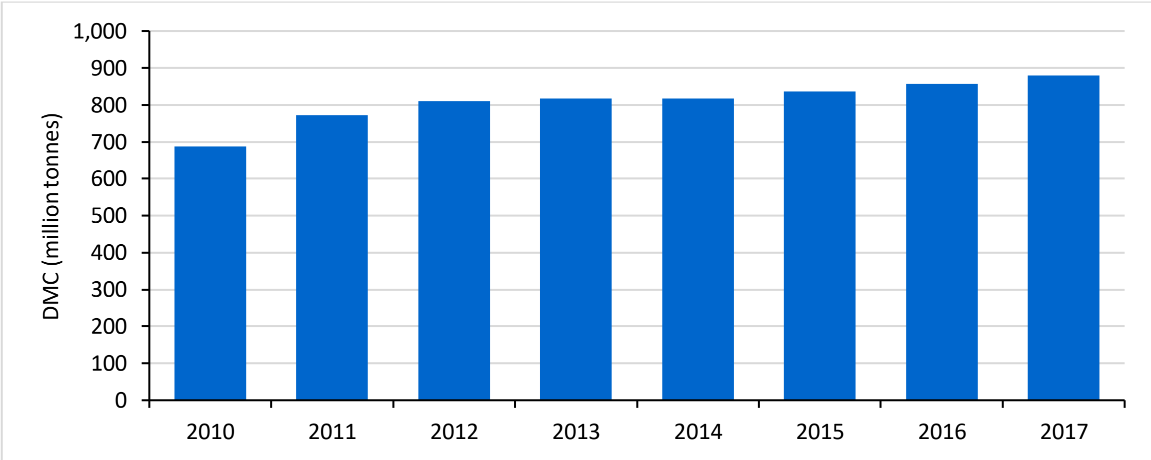


Figure 3-134 Material footprint of consumption in Thailand (2010 – 2017)

As presented in **Figure 3-134**, the total DMC in Thailand increased from around 0.7 billion tonnes to around 0.9 billion tonnes in just seven years. **Figure 3-134** shows the DMC of Thailand from 2010 to 2017. During the concerned duration (2010-2017) the DMC in the country showed a continuously increasing trend. The overall increase in the country's DMC was 28%. This increase in DMC of the country is due to the increasing population in the country (for reference see **Figure 3-128**). The country's population increased from 67.2 million in 2010 to around 70 million in 2017. Another reason can be the enhanced economic activities that caused an increase in the country's gross domestic product (GDP). From 2010 to 2017, the overall increase in the country's GDP was 34%.

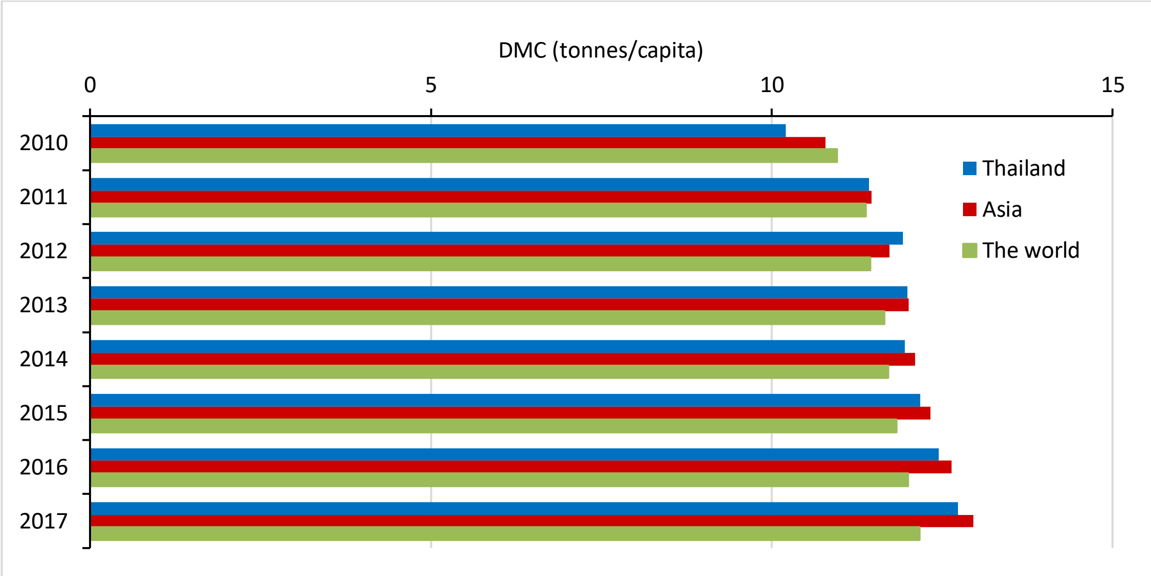


Figure 3-135 Per capita domestic material consumption in Thailand, Asia, and the World (2010-2017)

Figure 3-135 shows the per capita DMC of Thailand, the Asia region, and the world from 2010 to 2017. In 2010 the country's per capita DMC was 10.21 tonnes per capita which increased at a rate of 25% and reached around 13 tonnes per capita. It can be seen from the figure the country has experienced an increase of more than 2.5 tonnes per capita of DMC in 2017 as compared to 2010. Moreover, the country's per capita DMC is almost similar to that of overall Asia's per capita DMC which is higher than the global per capita DMC.

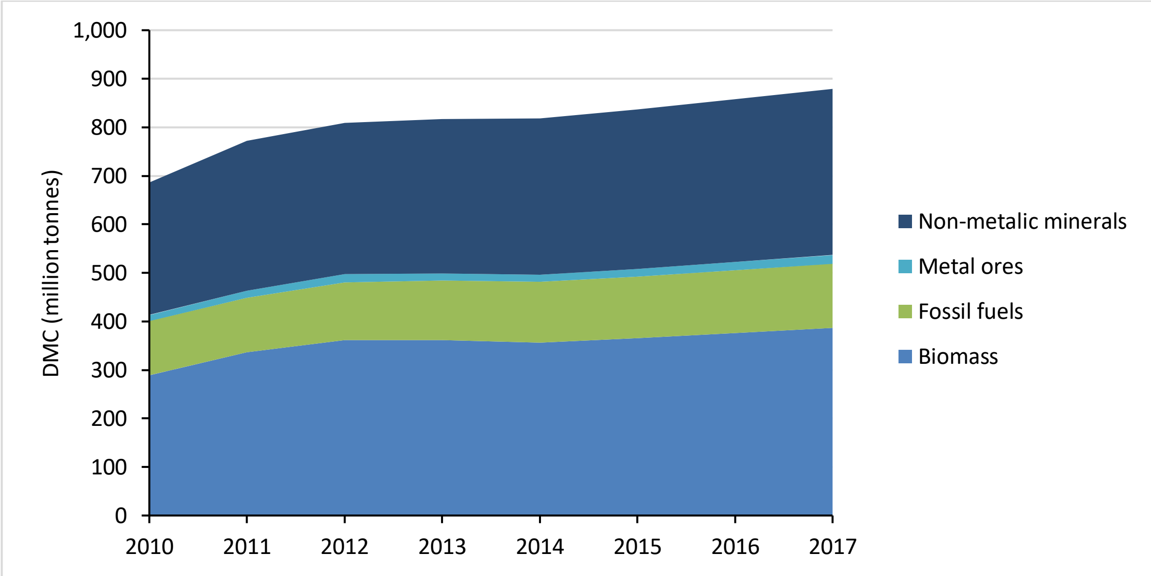


Figure 3-136 Domestic material consumption by material category in Thailand (2010 – 2017)

Figure 3-136 presents the category-wise DMC in Thailand. Different material categories show different growth trajectories. From 2010 to 2017, the average annual growth in the country's DMC of biomass, fossil fuels, metal ores, and non-metal minerals has increased at a rate of 0.036%, 0.022%, 0.035, and 0.071%, respectively. The overall total annual DMC of biomass, fossil fuels, metal ores, and non-metallic minerals increased with a rate of 34%, 19%, 33%, and, 26%, respectively, from 2010 to 2017. These statistics indicate that Thailand's economy is still highly dependent on its agriculture sector. The increased DMC of metal ores and non-metallic minerals shows enhanced activities in the country's manufacturing and infrastructure development sectors.

3.5.1.4 Energy Use

It is expected that the energy demand in Thailand will be increased by 78% by 2036, and gross domestic product (GDP) by 126%. [228] Thailand's energy policy focuses on reducing dependence on fossils (e.g., natural gas, coal, and oil) to enhance energy security. Therefore, renewables can play an important role to meet this gap. With the cost reduction of variable renewable energy, the conventional Thai market started giving way to alternative sources

[228] IRENA (2017), Renewable Energy Outlook: Thailand, International Renewable Energy Agency, Abu Dhabi. Available at: https://www.irena.org/-/media/files/irena/agency/publication/2017/nov/irena_outlook_thailand_2017.pdf

As shown in **Figure 3-137**, transport, industry, and residential are the main sectors in terms of final energy consumption in Thailand. Followed by the industrial sector, transportation has been Thailand's second most energy-intensive sector in terms of total final energy consumption. Energy consumption in the transportation sector was dominated by road transport, which plays a vital role in economic development. Therefore, the government attempted to promote the use of alternative energy in the transportation sector by increasing gasohol consumption. As a result, Thailand's biofuel usage has increased significantly.

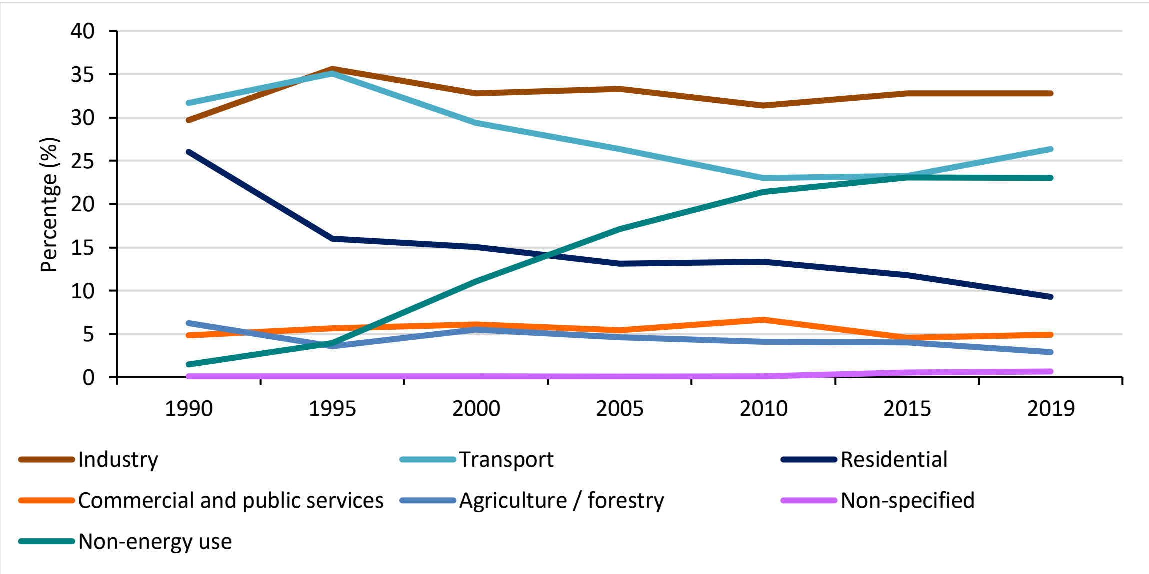


Figure 3-137 Sectoral share in total final energy consumption in Thailand (1990-2019) [229]

[229] IEA. (2022). International Energy Agency. Retrieved from https://www.iea.org/data-and-statistics/data-browser?country=WORLD&fuel=Energy%20consumption&indicator=TFCShareBySector

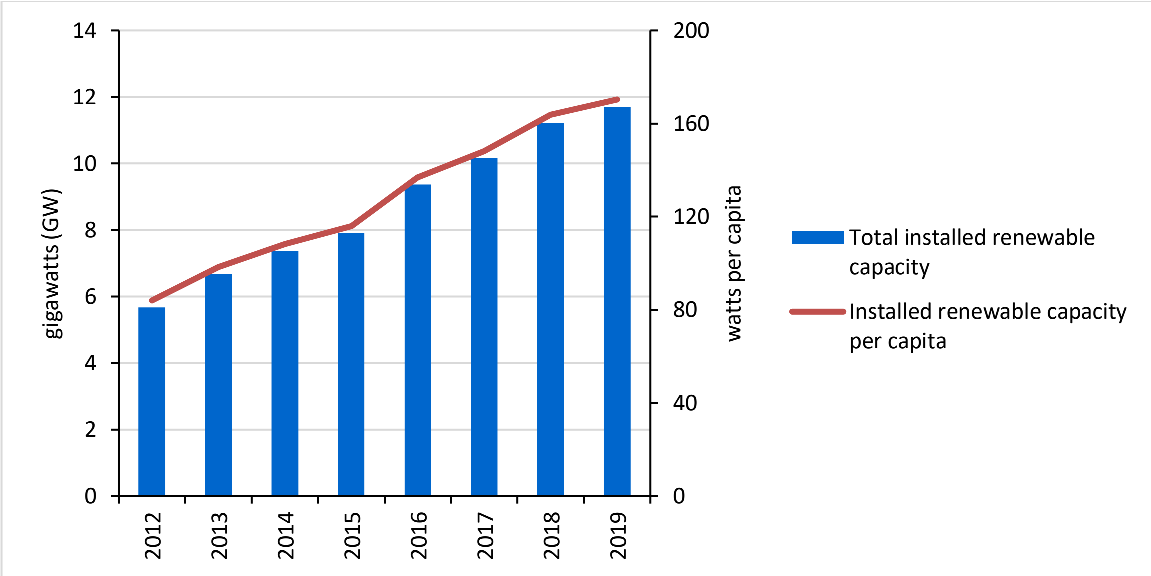


Figure 3-138 Installed renewable electricity-generating capacity in Thailand (2012-2019)[230,231]

The government has also run campaigns to encourage community participation in waste-to-energy conversion, waste sorting activities, and knowledge sharing with municipalities, communities, the general public, and students to improve understanding of waste management for environmental and energy purposes, to encourage waste-to-energy production. A ten years plan — Alternative Energy Development Plan which ran from 2012 to 2021 — intended to raise the percentage of alternative energy consumption by 25% of overall usage through the energy from waste [232]. The overall installed renewable electricity generation capacity has increased from 5.6 gigawatts to 11.7 gigawatts from 2012 to 2019 as shown in**Figure 3-138**.

Eco-Car programme-Excise tax in 2016; Thailand Alternative Energy Development Plan (AEDP 2015-2036) in 2015; Feed-in Tariff for Very Small Power Producers (VSPP) (excluding solar PV)

[230] UNEP. (2022). The United Nations Environment Programme. Available at: https://wesr.unep.org/downloader
[231] IRENA (2022).RENEWABLE CAPACITY STATISTICS 2022. *The International Renewable Energy Agency (IRENA)*. Available at: https://www.irena.org/IRENADocuments/Statistical_Profiles/Asia/China_Asia_RE_SP.pdf. [Accessed on April 2022]
[232] DEDE (2022). Thailand needs to promote Energy-from-Waste. *Department of Alternative Energy Development and Efficiency - Ministry of Energy, Thailand*. Available at:https://weben.dede.go.th/webmax/content/thailand-needs-promote-energy-waste. [Accessed on April 2022]

in 2014; Feed-in tariff for distributed solar systems in 2013; and Biodiesel blending mandate in 2012 are among the major programs/policy interventions by the Thai government[233].

Energy intensity

There has also been a significant increase in the energy demand, and it is also expected that the country's energy consumption would expand dramatically due to the rapid economic growth and increasing population. While considering the energy needs which are necessary to satisfy socio-economic growth demands, the government is also focusing on energy security and environmental conservation. To achieve this goal, a few of the considered measures are enhancing the energy efficiency on demand-side, while improving the energy performance to minimize the losses; and altering the energy source structure to reduce the dependency on fossil fuel, while promoting the efficiency and increasing the share of renewables in final energy production and consumption.

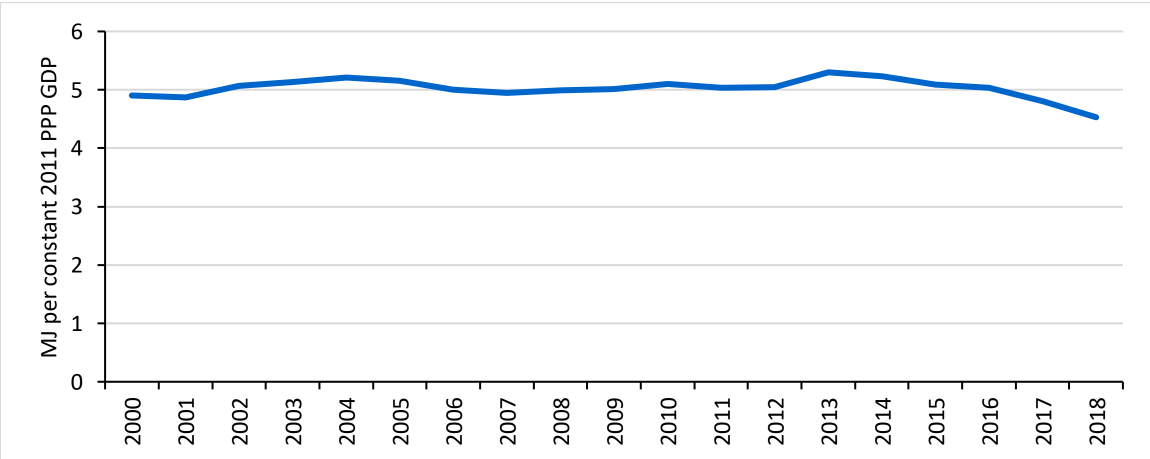


Figure 3-139 The Energy intensity of Thailand (2000-2018)

The energy intensity of Thailand has been fluctuating during the last two decades (between 2000 to 2018). However, it has significantly decreased after 2013 from 5.3 to 4.5 megajoules per constant 2011 PPP GDP as shown in **Figure 3-139**. A comprehensive strategy (i.e., Thailand 20-Year Energy Efficiency Development Plan 2011-2030) was developed with a clear goal of reducing energy intensity by 25% in 2030 compared to 2005, which equates to a 20% decrease

233 IRENA (2021). Thailand energy profile. *The International Renewable Energy Agency (IRENA)*. Available at: https://www.irena.org/IRENADocuments/Statistical_Profiles/Asia/Thailand_Asia_RE_SP.pdf. [Accessed on April 2022]

(or around 30,000 thousand tonnes of crude oil equivalent) in final energy consumption by 2030[234]. Energy Demand Situation and Trend; Energy Conservation Potential; Framework of the 20-Year Energy Efficiency Development Plan (2011-2030); Framework of the First 5-Year Work Plans; EEDP Mobilization and Success Factors were among the major topics covered in this plan.

3.5.1.5 Greenhouse gas emissions

The atmosphere contains lots of pollutants that are not always visible to the eyes, and they come from many sources. These air pollutants which deteriorate air quality and are catalysts to climate change are called greenhouse gases (GHG). Greenhouse gas emission is scientifically proven with evidence that it is the supreme cause of Earth's increase in temperature.[235,236] Greenhouse gases trap heat in the atmosphere and contribute to climate change. Climate change is one out of the six major sustainability problems alongside deforestation, scarcity of drinking water, poverty, hunger and loss of biodiversity, and population growth.[237]

The Asian region is home to many countries that are experiencing significant and rapid growth in several facets such as population, industries, economies, agriculture, etc. The growth of these sectors of most countries within the Asia-Pacific region has accelerated the increase in GHG emissions. Also, the rapid modernization and urbanization in the Asia-Pacific region increased the concerns on environmental issues [238] evidently with the mean surface temperatures in many countries within the region have increased averagely from 0.6°C to 1.2°C over 50 years since 1969 and are expected to keep on intensifying from 1.5 to 2°C by 2050.[239] The increase in surface temperature is evidence that GHG emissions from major

[234] EEDP (2011). 20-year Energy Efficiency Development Plan (EEDP) (2011-2030). *Ministry of Energy, Thailand.* Available at: https://policy.asiapacificenergy.org/sites/default/files/EEDP_Eng_0.pdf Retrieved on January 30, 2022.
[235] Andrew, J., and Cortese, C. 2011. Accounting for climate change and the self-regulation of carbon disclosures. Accounting Forum, 35(3): 130–138. DOI: https://doi.org/10.1016/j.accfor.2011.06.006
[236] Wolff, E., et al. 2014. Climate Change Evidence & Causes. National Acedemy of Sciences, 36. DOI: https://doi.org/10.17226/18730
[237] World Economic Forum. 2017. The Global Risks Report 2017 12th Edition. Insight Report.
[238] Ong, T., Teh, B., Goh, H., and Thai, S. 2015) ISO 14001 Certification and Financial Performance of Companies. Asia Pacific Management Accounting Journal, 10(2): 58–77.
[239] Begum, R.A 2017. Tackling Climate Change and Malaysia's Emission Reduction Target. Available at: http://magazine.scientificmalaysian.com/issue-13-2017/tackling-climate-change-malaysias-emission-reductiontarget/

sources are increasing. The Asia-Pacific area accounts for more than half of the world's total greenhouse gas emissions (GHGs), with six of the top ten worldwide polluters located there. The main GHG emissions can be categorized into GHG from agriculture, GHG from transportation, and GHG from industrial sectors in six countries within the Asia Pacific region. It is thus, worthy to investigate the strategies employed by countries within the Asia Pacific region to mitigate these emissions. Changing the behaviors that deteriorate the health of the Earth needs an extensive understanding of climate change and its influence[240] and the Asia Pacific region is not an exception. Therefore, many countries, cities, and organizations around the globe are estimating their greenhouse gas emissions and developing strategies to reduce their emissions.

The energy sector, which includes power generation, transportation, industries, buildings, and households, is a major source of greenhouse gas (GHG) emissions in Thailand. In 2013, Thailand contributed less than 1% of world emissions. As demonstrated in **Figure 3-140**, Thailand's overall GHG emissions have continually increased. Thailand submitted its nationally appropriate mitigation action (NAMA) in 2014, pledging to cut greenhouse gas emissions by 7-20% by 2020, compared to the predicted business as usual level. To date, the NAMA implementation has provided a promising mitigation effect, putting Thailand on course to fulfilling its 2020 target. Thailand, as a signatory to the Paris Agreement, submitted its (intended) nationally determined contribution ((I)NDC) in 2015, pledging to cut its greenhouse gas emissions by 20-25 percent by 2030 compared to the expected business as usual level.

[240] Daud, Z. M., Mohamed, N., and Abas, N. 2015. Public knowledge of climate change: Malaysia's perspective. International Conference on Human Capital and Knowledge Management.

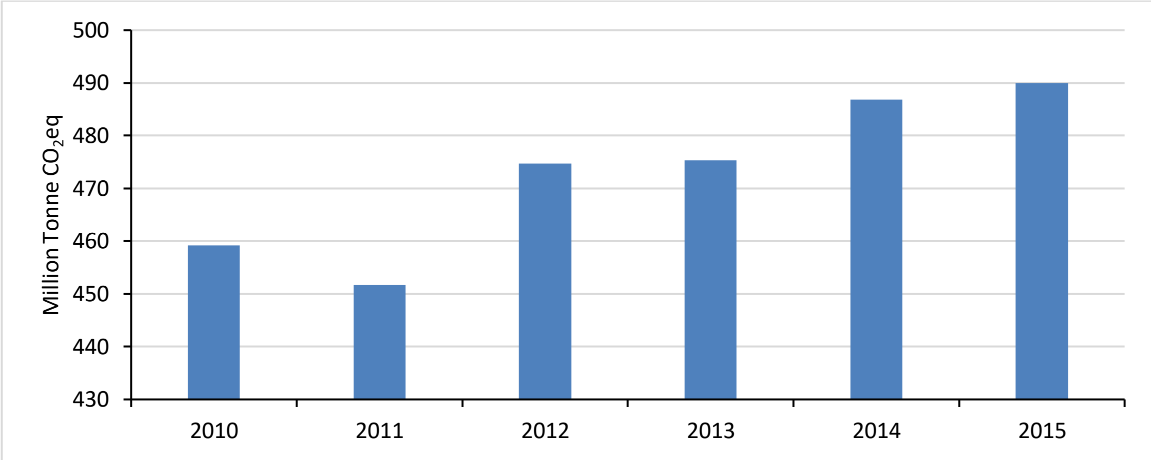


Figure 3-140 Total GHG emissions from Thailand (1980 - 2015).

Greenhouse gas from major sectors

Greenhouse gas from energy use

Emissions from the energy sector grew strongly from 16 Mt in 1971 to 198 Mt in 2000 in Thailand[241]; Population expansion, economic (income) growth, growth in emissions-intensive economic sectors (structure), and growing usage of emissions-intensive technologies are all driving these emissions (fuel mix). Thailand's energy demands are largely met by fossil fuels. The economic structural shift from emissions-intensive heavy manufacturing to less-emissions-intensive light manufacturing and services sectors has also contributed to a lower rate of emissions rise in recent years.

In 2013, GHG emissions from energy use accounted for over 74% of total GHG emissions. However, emissions growth has grown by 1.6% since 2010 – 2015 as shown in **Figure 3-141**. **Figure 3-142** shows that GHG resulting from transportation has equally been on the increase. To minimize GHG emissions from the energy sector, Thailand suggested in its NAMAs strategy for the energy and transportation sectors a reduction of 7% to 20% below its business as usual (BAU) level. Furthermore, in 2015, Thailand's Ministry of Energy (MOE) developed energy master plans, which directly affect the reduction of TFEC and GHG emissions. They are Energy

[241] Sandu, S., Yang, M., Mahlia, T. M. I., Wongsapai, W., Ong, H. C., Putra, N., & Rahman, S. M. A. (2019). Energy-Related CO2 Emissions Growth in ASEAN Countries: Trends, Drivers and Policy Implications. *Energies*, *12*(24), 4650. https://doi.org/10.3390/en12244650

Efficiency Plan 2015-2036 (EEP2015), Alternative Energy Development Plan 2015-2036 (AEDP2015), and Thailand Power Development Plan 2015-2036 (PDP2015). These plans are concerned with energy security, the economy, and the environment. As a result, the plans included fuel diversification in order to reduce reliance on fossil fuels. It is imperative to state that, GHG resulting from households has steadily decreased as shown in **Figure 3-143**.

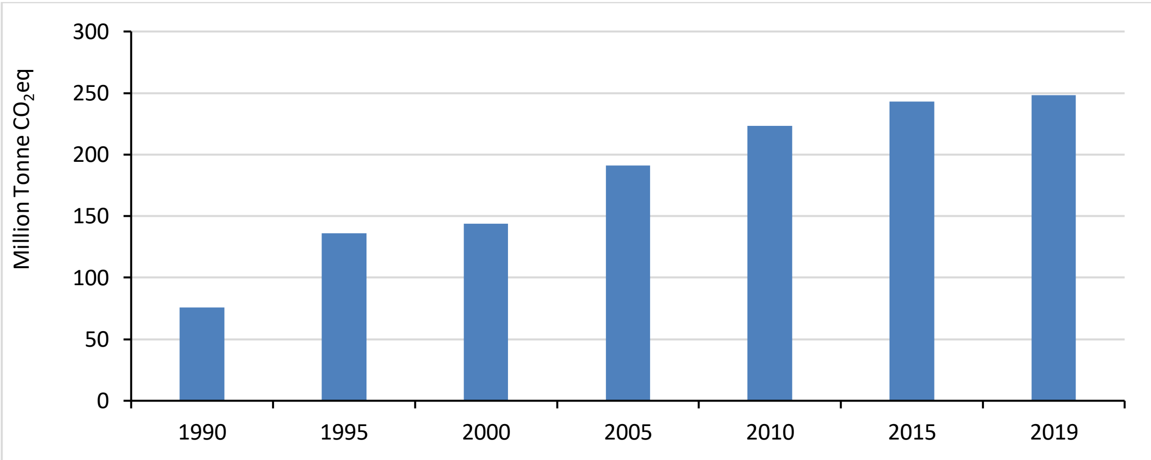


Figure 3-141 GHG emissions from energy sector in Thailand (1990 - 2019)

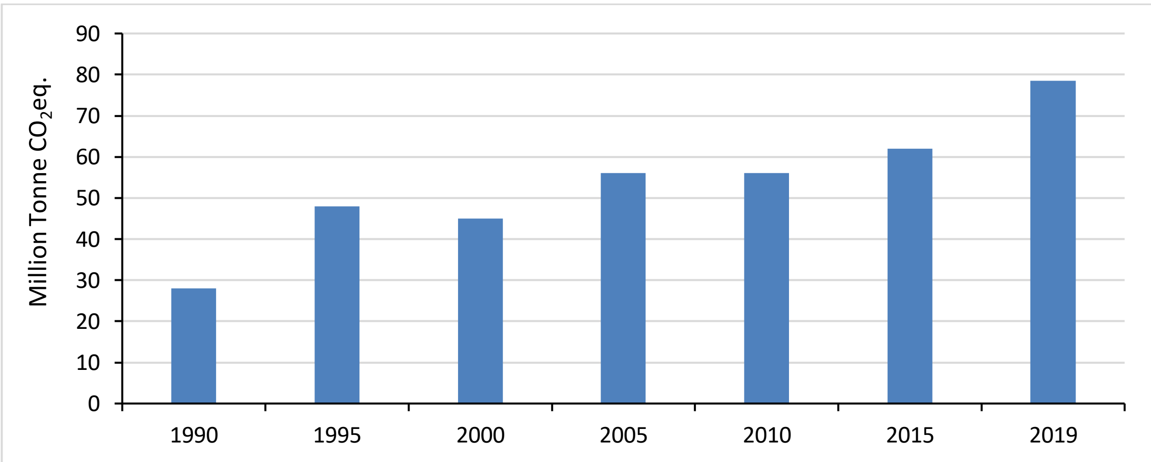


Figure 3-142 GHG emissions from transportation in Thailand (1990 - 2019)

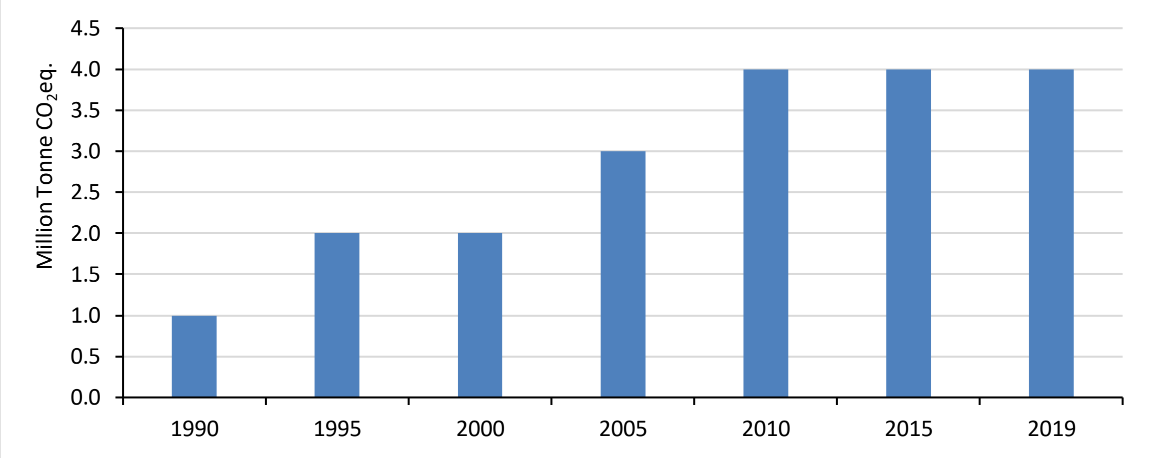


Figure 3-143 GHG emissions from household in Thailand (1990 - 2019)

Greenhouse gas from agriculture

Thailand has a population of approximately 60 million people, the majority of whom live in rural villages and rely on agriculture for their living. Agriculture plays an unusual environmental function on a global scale: it is both a sufferer and a contributor to climate change caused by greenhouse gas emissions. In 2013, Thailand's agriculture sector accounted for 21.9 percent of the country's net GHG emissions. As illustrated in **Figure 3-144**, GHG emissions from agricultural operations have steadily reduced since 2013.

Recognizing that field burning of agricultural residues contributes to GHG emissions, the Ministry of Agriculture and Cooperatives has promoted the recycling and reuse of rice straws and other agricultural residues by converting them to organic fertilizer and/or soil conditioner to return carbon and natural nutrients to agricultural land. Relevant authorities have effectively initiated awareness raising, capacity training, farmer network building, and pilot projects, resulting in over 1,000 trained farmers and the termination of field burning of agriculture leftovers across an area of 108,945 hectares.[242]

[242] *Thailand's First Biennial Update Report Under the United Nations Framework Convention on Climate Change*. (2015). https://unfccc.int/resource/docs/natc/thabur1.pdf

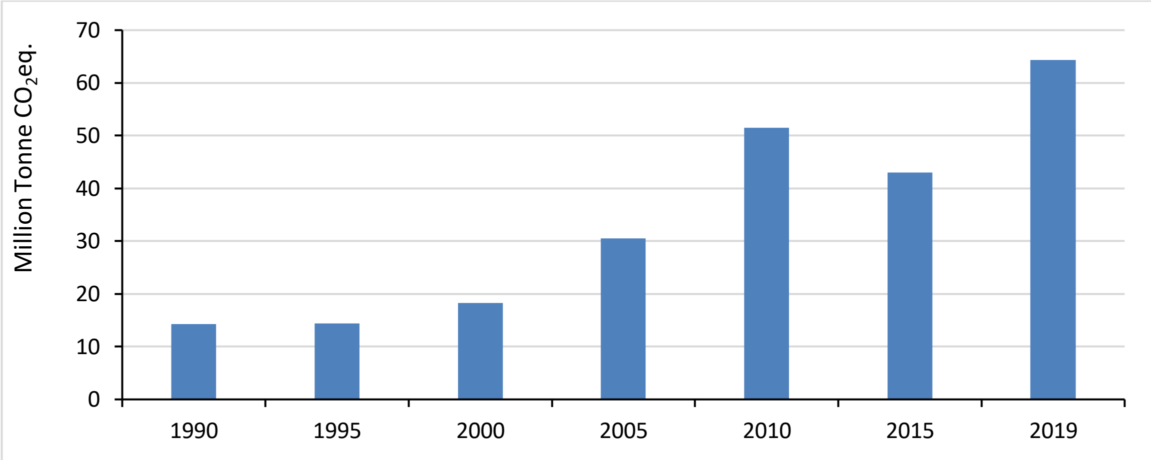


Figure 3-144 GHG emissions from Thailand's agricultural sector (1990 – 2019)

Recycling at SCG tiles
The design practices at SCG are made to solve the firm's environmental impacts. SCG ceramics are aimed at better management of energy, increasing the share of clean energy, water use reduction, pollutant emission reduction, and waste reduction. Thus, SCG is taking necessary measures to be an environmentally friendly firm. Proof of this is that the annual GHG emission value of SCG stands at around 0.28 million tonnes of CO_2e. At the same time, more than half of it is being caused because of grid mix electricity (i.e., a high share of it is being produced from natural gas and coal). Therefore, energy conservation and the use of clean energy (e.g., solar energy) support the company's policy of eco-friendly business. Another factual proof is that the GHG emissions per tonne of the product in the company are around 234 kg CO_2eq per tonne of the product, while the indirect emissions from the grid mix electricity are around 126 kg CO_2e. The design practices implemented at SCG to achieve the above-stated environmental benefits were the installation of solar panels on rooftops (4.7 MWh), energy conservation through waste heat recovery (air to air heat exchanger for drying the tiles) and installing LED tube lights, water management (reduce, reuse, and recycle), and installing the equipment for air cleaning (i.e., bag filter, wet scrubber, and eliminating the source of contaminations). The noteworthy proud achievement of the company was a significant reduction of GHG emissions (i.e., an annual reduction of around 4849 tonne CO_2eq) through energy

conservation and solar energy generation. These activities contribute to energy conservation, clean energy production, GHG emission reduction, cost reduction, and resource efficiency.

These SCG processes have led to the achievement of several environmental benefits as they helped to reduce GHG emissions of the company to about 4849 tonne CO_2eq *(i.e., around 3747 tonnes CO_2eq from solar electricity generation, 329 tonne CO_2eq from waste heat recovery, and 773 tonne CO_2eq from installing LED lights). Better health conditions were achieved due to the reduced emissions, these emissions in liquid, and water emissions well within the legal limits. Secondly, the waste heat energy through air-to-air heat exchangers resulted in the conservation of around 5560 million BTU per year of energy from natural gas. The installation of LED and High Bay lights resulted in the saving of around 1330 MWh of electricity per year. Lastly, the wastes are properly managed under 3R principles (i.e., reduce, reuse, and recycle).*

3.1.1.6 Material use and HDI

The relationship between the Human Development Index (HDI) – a measure of human development – and the growth in material usage in Thailand from 2010 to 2017 was explored in this section of the report. From 2010 to 2017, **Figure 3-145** depicts the relationship between the human development index (HDI) and material consumption (DMC per capita), and material footprint (MF per capita) in Thailand.

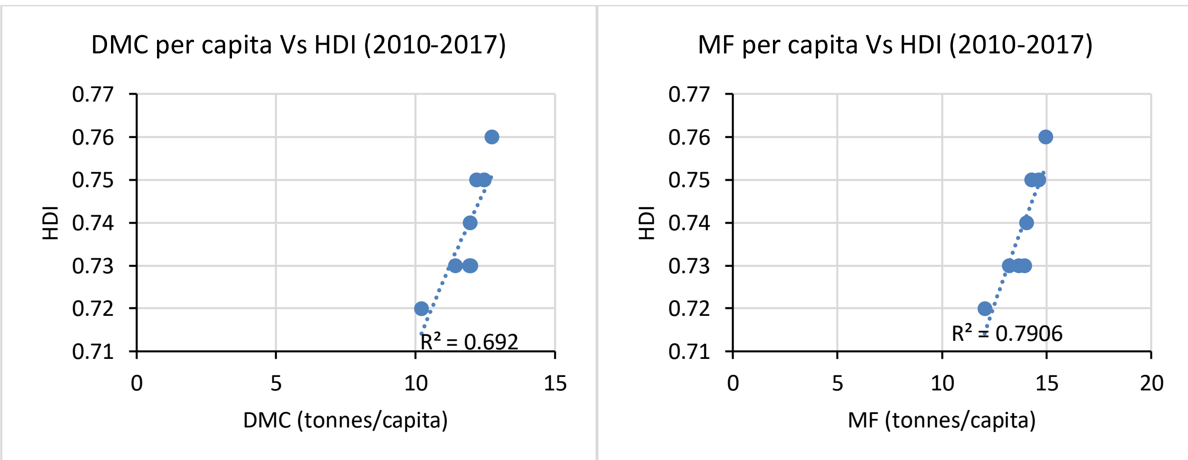
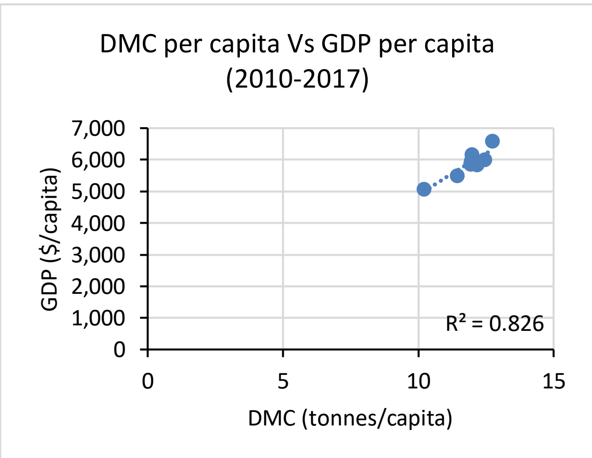


Figure 3-145 The relationship between the human development index (HDI) versus material use (DMC per capita), and material footprint (MF per capita) for Thailand (2010-2017).

Figure 3-145 shows that the relationship between direct material use and HDI in Thailand is weaker as compared to the relationship between the material footprint of consumption and HDI. Moreover, for Thailand, the correlation between material footprint and HDI is stronger as compared to direct material use and HDI as the value of correlation coefficient "r" between material footprint and HDI, and direct material use and HDI was 0.9013 and 0.8458, respectively, from 2010 to 2017. This is because the material footprint of consumption represents the material used for the production systems that provide substantial opportunities for employment creation and income generation.

3.5.1.7 Economic Growth

In this section, GDP is used as a complementary indicator to show how overall production activities provide a different perspective on domestic material consumption and material footprint in Thailand. The time series covered is from 2010 to 2017. **Figure 3-146** shows the relationship between the GDP per capita (USD/capita) versus material use (DMC per capita), and material footprint (MF per capita) for Thailand from 2010 to 2017.



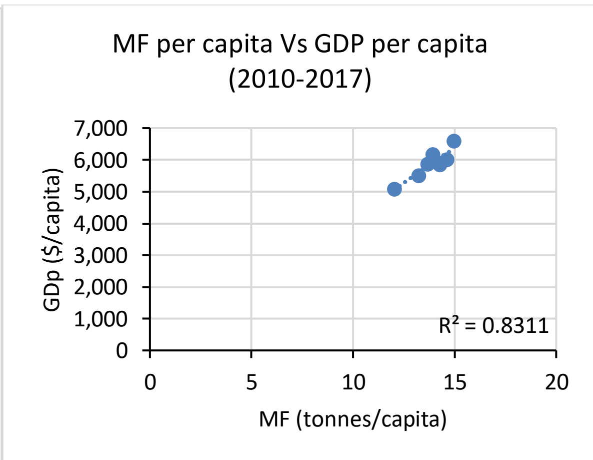


Figure 3-146 The relationship between the GDP per capita versus material use (DMC per capita), and material footprint (MF per capita), Thailand (2010, 2017)

In **Figure 3-146**, Thailand's DMC per capita (tonnes/capita) and material footprint per capita (tonnes/capita) are plotted against GDP per capita for 2010 and 2017. It can be seen that both

DMC per capita and material footprint per capita has a positive relationship with GDP per capita. However, the relationship between DMC per capita and GDP is slightly stronger as the value of correlation coefficient "r" between direct material use and GDP, and material footprint and GDP was 0.9149 and 0.9137, respectively, from 2010 to 2017. It shows that as more and more material is employed in the production system the countries attain higher economic growth. However, it is unfavorable for the decoupling of material use from economic development. To achieve decoupling, Thailand will have to adopt more advanced and material-efficient production systems.

3.5.1.8 Physical trade balance

Agricultural sector

Thailand is a leading agricultural exporter and crop was its main exported agricultural product which accounted for 99% (**Figure 3-147**) .Rice, tapioca, sugar, and pineapple were major agricultural products exported by Thailand.[243] The trade deficit grew on average by 2% from -16.4 million tonnes in 2010 to -20.5 million tonnes in 2017 .The exported crops only declined by 7%in 2012. The PTB per capita was maintained at around -0.3 tonnes per capita from 2011 to 2017 with an average increase of 2 from 2010 to 2017, as shown in **Figure 3-148**.

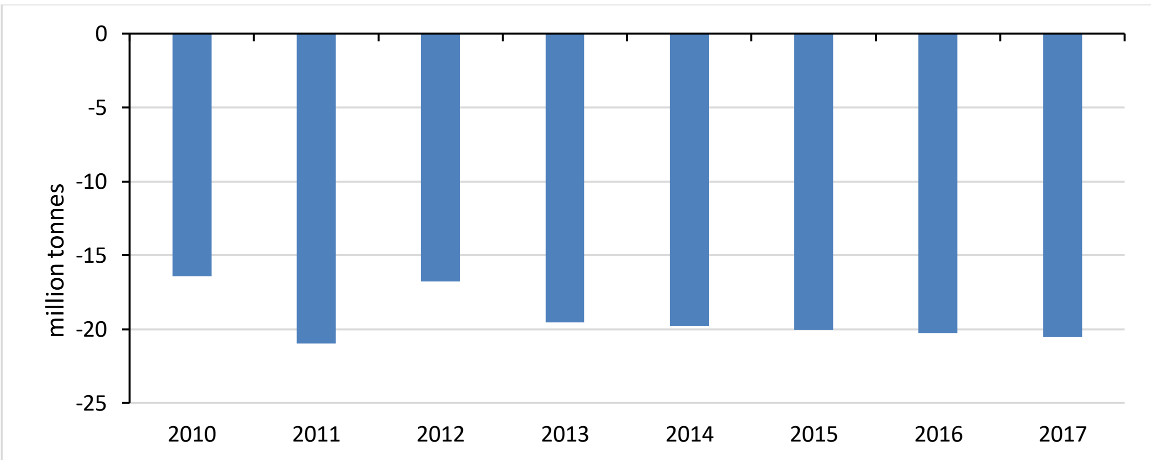


Figure 3-147 Physical trade balance by agricultural sector in Thailand, 2010 to 2017

[243] Britannica (2019). *Trade of Thailand*. https://www.britannica.com/place/Thailand/Trade

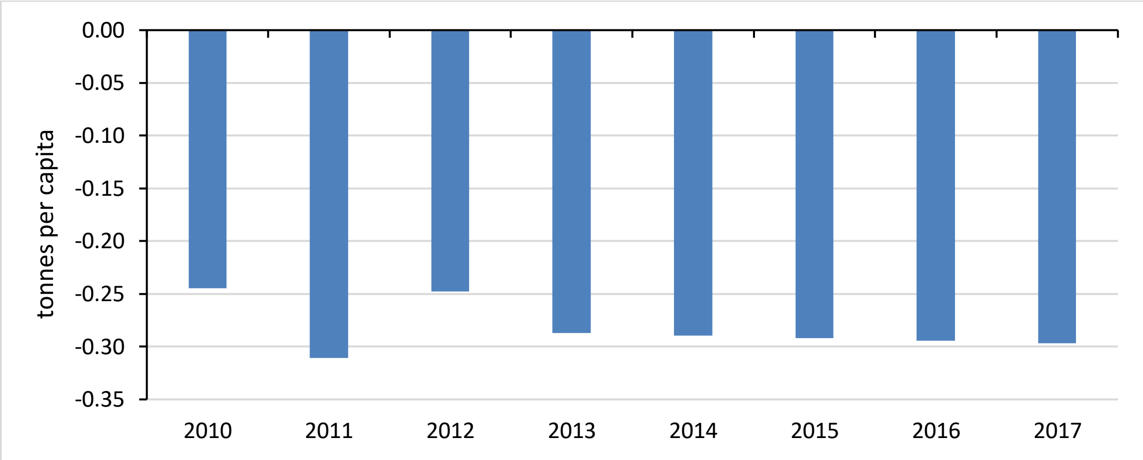


Figure 3-148 Physical trade balance per capita by agricultural sector in Thailand, 2010 to 2017

Food sector

Thailand's deficit in the food sector in **Figure 3-149** increased from 17 million tonnes in 2010 to 20 million tonnes in 2017 with an average growth of 2%. The main exports were food crops, accounting for 97% and the remaining 3% was from wild catch and harvest. In 2011, Thailand encountered a flood crisis, which harmed exports .The exported food in 2012 fell by 7%. **Figure 3-150** shows PTB per capita was -0.30 tonnes per capita in 2017 which increased by 16% compared to 2010 .

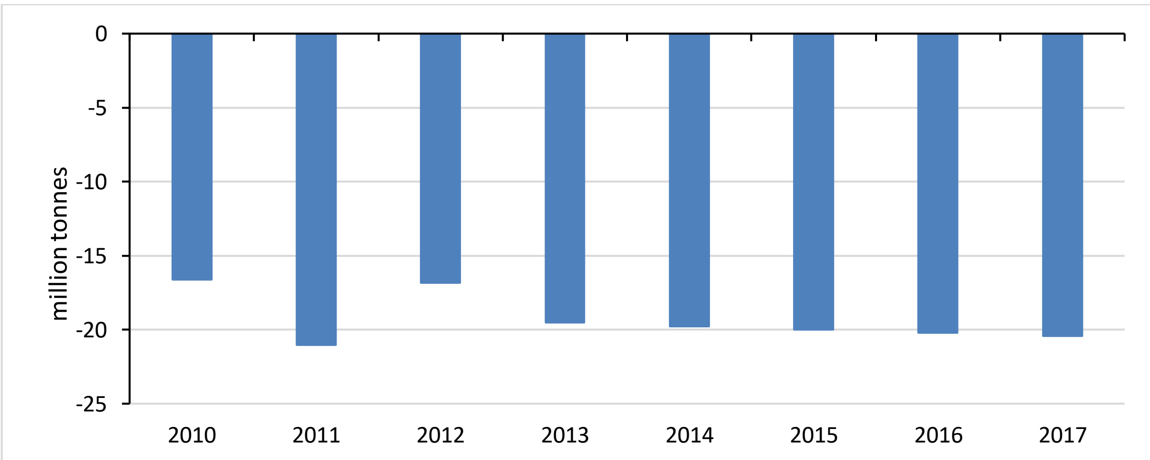


Figure 3-149 Physical trade balance by food sector in Thailand, 2010 to 2017

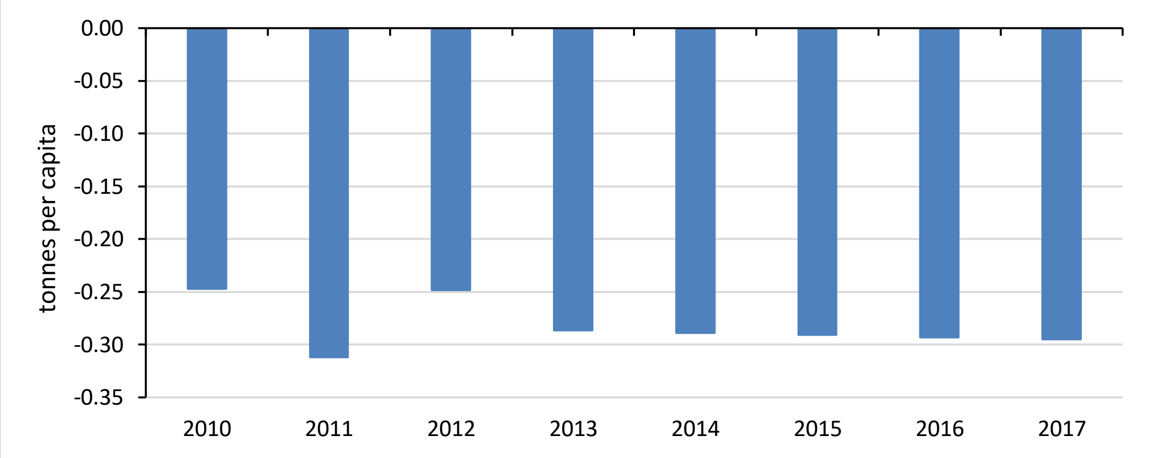


Figure 3-150 Physical trade balance per capita by food sector in Thailand, 2010 to 2017

Construction sector

Thailand's trade deficit fell on average by 5 % from -34 million tonnes in 2010 to 27 - million tonnes in 2017, as shown in **Figure 3-151**. This is caused by the increase in construction activities including public and private construction investment.[244] The PTB per capita was -0.34 tonnes per capita in 2017 which decreased by 28% from 2010 (**Figure 3-152**).

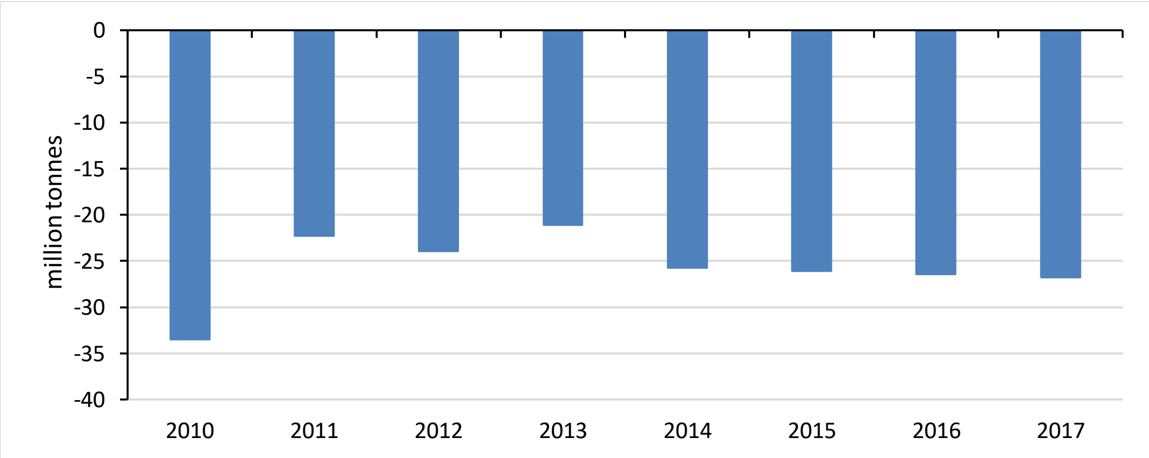


Figure 3-151 Physical trade balance by construction sector in Thailand, 2010 to 2017

[244] Mahattanalai, T. (2019). *Industry Outlook 2019-2021: Construction Contractor*. https://www.krungsri.com/th/research/industry/industry-outlook/Construction-Construction-Materials/Construction-Contractors/IO/Industry-Outlook-Construction-Contractors.

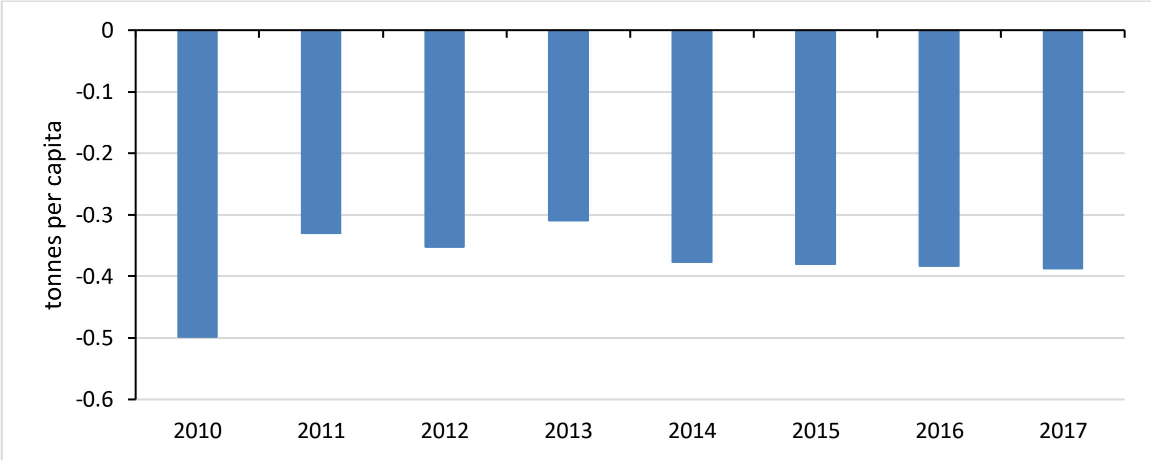


Figure 3-152 Physical trade balance per capita by construction sector in Thailand, 2010 to 2017

3.5.2 Consolidated discussion

International trade plays an important role in Thailand as the economy of the country is mainly export-driven. The top export destination of Thailand's products is the USA. In 2020, Thailand exported goods equivalent to a total of $226.7 billion. Moreover, In Thailand, renewable energy consumption, material use, and GHG emissions are increasingly driven by the increase in population and economic growth, influencing consumption and production patterns of natural resources. However, the reduced availability of water is causing a reduction in water use in the food sector. On the other hand, land use in the agricultural sector is increased in the agriculture sector which may be due to the economy's dependence on the agricultural commodities. The country is implementing its National Family Planning Program[245] to control the increasing population, the Eighth Trade Policy Thailand[246] for a better trade balance, and Environmental Quality Management Plan 2017-2036[247] to take measures for protecting the environment. A summary of SCP indicators and issues considering the DPSIR framework for Pakistan is presented in **Table 3-7**.

Table 3-7 A summary of SCP indicators and issues considering the DPSIR framework for Thailand.

245 https://overpopulation-project.com/thailand-success-story-family-planning-with-creativity-and-humor/
246 https://www.wto.org/english/tratop_e/tpr_e/tp500_crc_e.htm
247 http://www.tshe.org/wp-content/uploads/2017/06/ONEP_Nawarat-1.pdf

Derivers/ pressures	State/ impact	Responses
- Increasing population (67 million in 2010 to around 70 million in 2017) - Increased economic activity (USD 5080 per capita in 2010 to USD 6600 per capita in 2017 and total GDP from USD 341 billion in 2010 to USD 456 billion in 2017)	- Domestic material consumption increased from 0.7 billion tonnes in 2010 to around 0.9 billion in 2017 - additional potentials are solar PV, increasing from 6 GW to almost 17 GW, and onshore wind, doubling from 3 GW to 6 GW - The agriculture sector is the major contributor to land use. • land use of the agriculture sector was increased to 4.61 million hectares in 2018 which was 2.38 million hectares in 1990. - The food sector is the major contributor to water use. • Water use in the food sector was 9.4 billion cubic meters in 2018 - The physical trade balance is negative for all the considered sectors - GHG emissions increased from around 460 million tonne CO_2eq. in 2010 to	- National Family Planning Program to control the population growth - The Eighth Trade Policy Thailand for better trade balance. - Environmental Quality Management Plan 2017-2036 to take measures for protecting the environment.

Derivers/ pressures	State/ impact	Responses
	around 490 million tonne CO_2eq. in 2015.	

3.6 Viet Nam

- The total GDP of the country has increased sharply from $US 116 billion in 2010 to $US 224 billion in 2017.
- Resource use (renewable energy, material, water, and land use) and GHG emissions are increasing over time.
- Rapid industrialization, economic development, and urbanization are the major SCP driving forces.
- Doi Moi Economic Reforms and various other initiatives are being implemented for achieving sustainable development.

Vietnam is a Southeast Asian country situated on the Indochina Peninsula. China to the north, Laos, and Cambodia to the west, and the Pacific Ocean's Eastern Sea (South China Sea) to the east, it has a 4,550 km long land border. Hills, mountains, deltas, coastlines, and the continental shelf make up the country's diversified topography, which reflects the country's long history of geology and topography creation in a monsoon-heavy, humid environment with extreme weather. From the northwest to the southeast, the terrain is lower, as can be seen in the flows of major rivers.[248] Viet Nam has made great strides in population growth. In 2010, Viet Nam's total population was around 88 million that was increased at a rate of 7.5% and reached more than 94 million in 2017 as presented in **Figure 3-153**. Ranked as the 15th largest country in population, currently, Vietnam's population is more than 98 million, which is equivalent to 1.25% of the total global population.[249] The population of the country is expected to reach 100 million by the end of 2024 and 109.78 million in 2054.[250] Vietnam, on the other hand, has been attempting to establish a policy to slow the rate of population increase. The program arose in response to the findings of the Democratic Republic of Vietnam's 1960 Census, and it reflected long-standing concerns about food shortages as well as a desire to promote women's health and welfare. The strategy was extended across the entire country after the reunification in 1975. Since then, Vietnam's growth rate has slowed, indicating that the national drive for fewer families is having an impact on strongly held

[248] https://vietnamembassy-usa.org/vietnam/geography
[249] https://www.worldometers.info/world-population/vietnam-population/
[250] https://worldpopulationreview.com/countries/vietnam-population

attitudes and views. Although Vietnam's fertility decrease is not the quickest in the world, the effectiveness of the country's population management has permanently altered the country's population growth prospects.

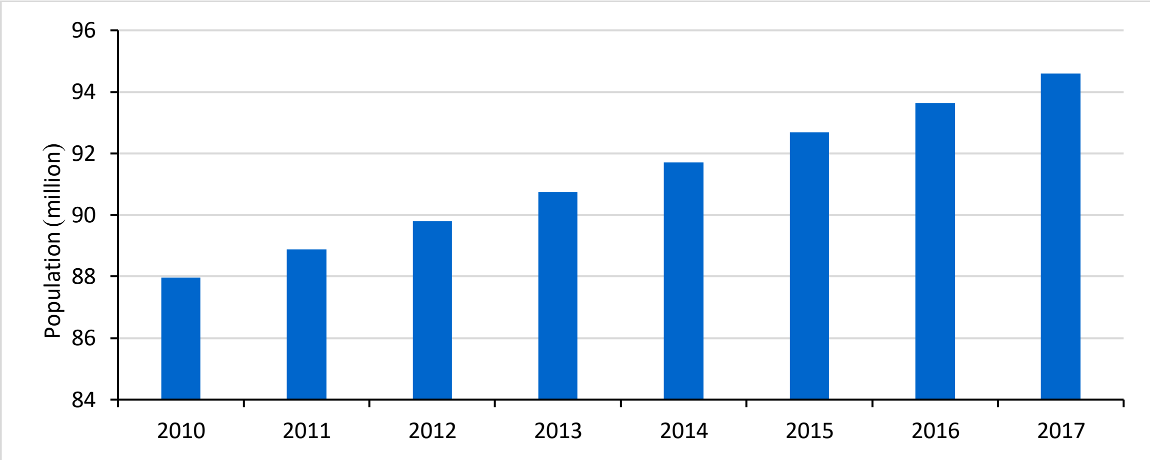


Figure 3-153 Population of Viet Nam (2010-2017)

Parallel to demographic growth, Viet Nam is rapidly moving towards urbanization as the share of the urban population in countries total population continuously increases. Viet Nam's urban population grew at a rate of around 3% per year between 2010 to 2020. The share of the urban population of the country in 2010 was above 30% amounting to around 27 million increased to more than 37% and reached 36 million in 2020.[251] Viet Nam's total urban population and urban population as a %age share of the total population are presented in **Figure 3-154**.

[251] https://datacatalog.worldbank.org/public-licenses#cc-by

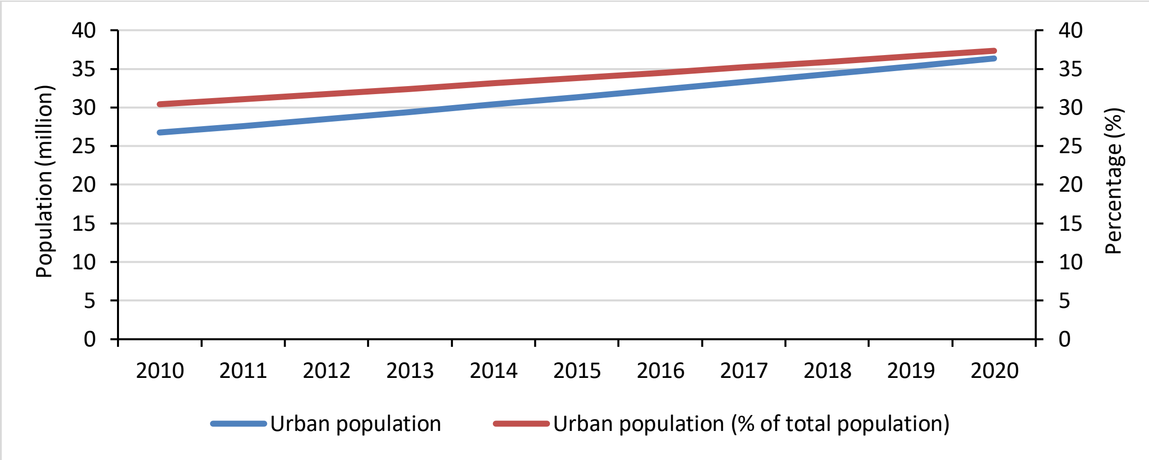


Figure 3-154 Urban population of Viet Nam (2010-2020)

Viet Nam also has huge achievements regarding economic development. The Doi Moi economic reforms in Vietnam have resulted in a period of high GDP growth rate. From 1990 to 2000, the Vietnamese economy maintained annual growth rates above 7%.[252] The country continued this growth from 2001 t0 2010 by maintaining a growth rate of between 6-7%.[253] In 2010 the total GDP of Viet Nam was around $US 116 billion which experienced an overall increase of 93% and reached around $US 224 billion in 2017. The per capita GDP has also increased almost two folds from 2010 t0 2017 from $UD 1,318 to $US 2,366, respectively (See **Figure 3-155**).

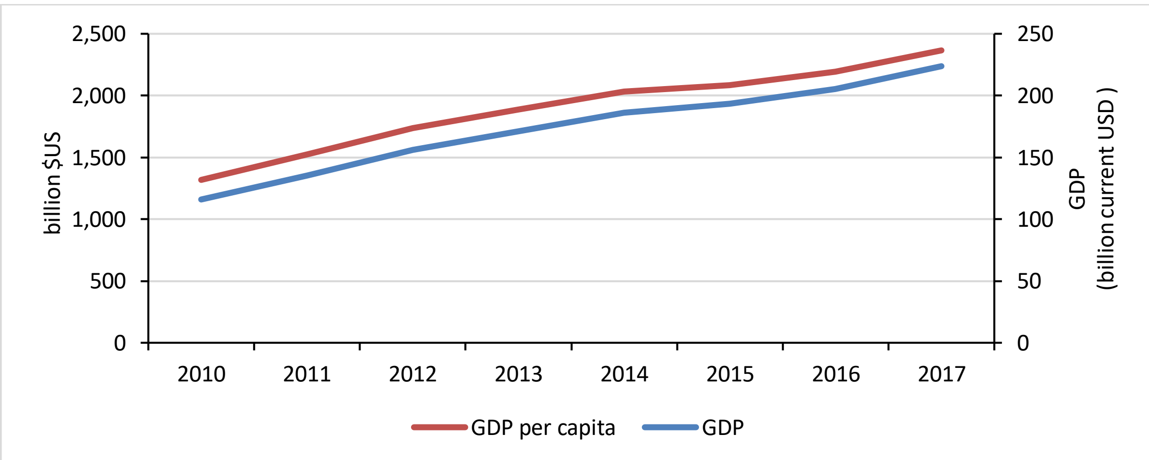


Figure 3-155 Gross domestic product (GDP) of Viet Nam (2010-2017)

[252] https://mpra.ub.uni-muenchen.de/29391/1/MPRA_paper_29391.pdf
[253] http://web.pdx.edu/~ito/Vietnams%20Current%20Economic%20Situation%20and%20Future%20Prospects.pdf

Alongside economic growth, Viet Nam is swiftly moving towards industrialization. In 2016, the Fourth Industrial Revolution (4IR) gained attention in Viet Nam during the 4th plenum of the 12th Central Committee. As a result of policymakers' interest in 4IR, the intellectual and business community began to participate in the negotiations in different formats. There's no doubt that public speeches, lectures, and presentations by Vietnamese policymakers are helping to spark domestic debate. However, these are primarily political rhetorical and have had no actual policy repercussions.[254] On the other hand, between 2006 and 2016, Vietnam rose 27 places in the Competitive Industrial Performance (CIP) Index passed by the United Nations Industrial Development Organization (UNIDO) – which tracks the progress of the country's manufacturing sector. The Vietnamese government announced an action plan implementing Resolution No 23/NQ/TW in 2020, which lays out a national economic policy from 2030 to 2045. The main target of that resolution is to focus on three key factors viz, value-added products, exports, and employment opportunities. This shows that Viet Nam is well on track to achieve its goal of being among the top three Southeast Asian countries by 2030.[255]

Both economic growth and achievement regarding industrial development have participated to accomplish significant poverty reduction in Viet Nam as the Gross National Income (GNI) and GNI per capita income in the country have shown a tremendous improvement during the last decade. The total GNI in the country was more than $US 111 billion in 2010 which experienced a huge increase of 129% and reached around $US 256 billion. On the other hand, from 2010 to 2020, the GNI per capita of the country increased by 107% and reached $US 2625 from $US 1268 (see **Figure 3-156**).[256]

[254] https://library.fes.de/pdf-files/bueros/vietnam/14005.pdf
[255] https://www.vietnam-briefing.com/news/vietnam-sets-ambitious-goals-in-new-national-industrial-policy.html/
[256] https://datacatalog.worldbank.org/public-licenses#cc-by

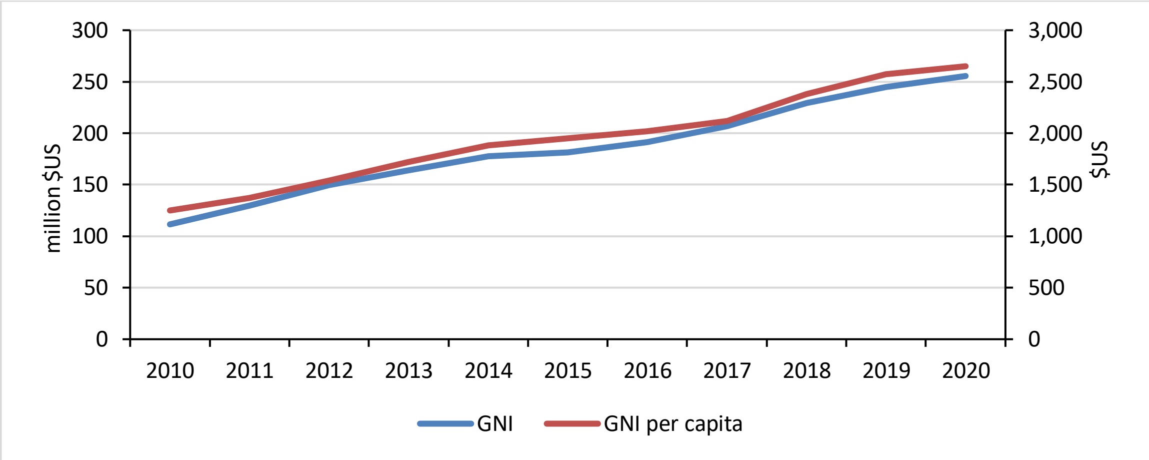


Figure 3-156 Gross National Income (GNI) of Viet Nam (2010-2020)

However, sustaining this impressive economic growth, industrial development, urbanization, and poverty reduction achievements requires a long-term perspective in which sustainable development plays a key role. As the World Bank noted, “growth will be illusory if it is based on mining soils and depleting fisheries and forests”. Natural resources represent a larger share of wealth for developing countries like Vietnam. Although the share of natural resources falls as the income level of the country increases. This is because overall wealth rises as income rises, and the total value of natural resources rises as income rises. The percentage of produced capital remains roughly stable across income categories, but the share of intangible capital rises with income. [257] A detailed analysis of Viet Nam’s profile through the DPSIR framework is presented in **Figure 3-157**. The indicators for natural resource use (material, energy, land, water, etc.) in the context of Viet Nam are presented in the following section.

[257] https://mpra.ub.uni-muenchen.de/29391/1/MPRA_paper_29391.pdf

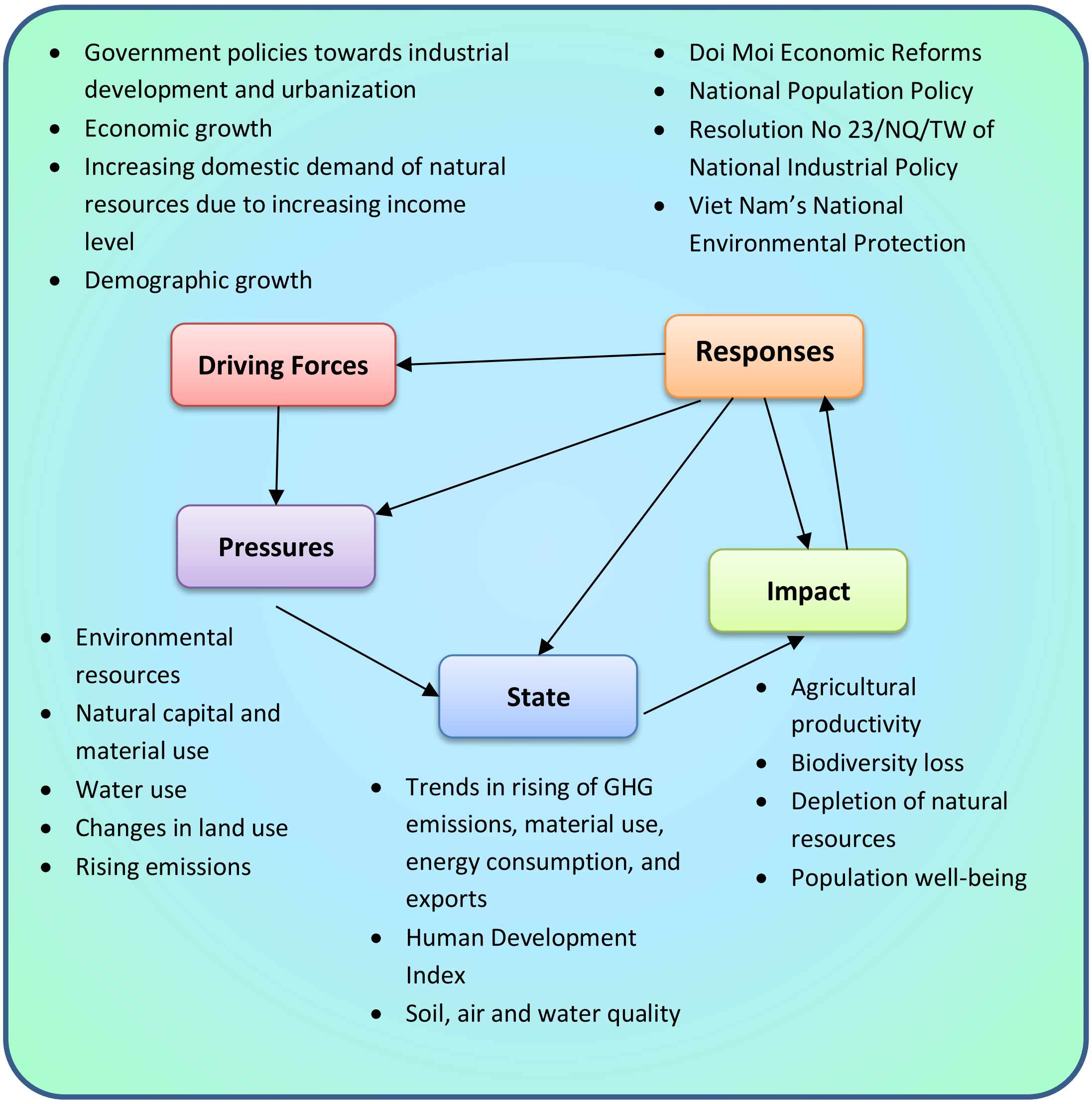


Figure 3-157 DPSIR framework of Viet Nam

Product-policy frameworks - National Action Plan on Sustainable Consumption and Production 2021 – 2030.
Due to the astronomic growth of the industrial activities which has brought about some adverse environmental, adopting the Sustainable Consumption and Production (SCP) by incorporating a life-cycle approach through the circular economy and tailoring it to socio-economic setting to provide solutions that mitigate environmental burdens is of utmost importance.

Product-policy frameworks - National Action Plan on Sustainable Consumption and Production 2021 – 2030.

Thus, National Action Plan (NAP) intends to develop initiatives, regulations, and incentive-based approaches to stimulate investment in manufacturing and distributing sustainable products in two stages during the next decade, namely by 2021-2025 and by 2030. *This comprehensive policy for sustainable consumption and production applies to all sectors. The policy prioritizes clean energy, waste collection, recycling, and reuse.* It also facilitates the formation of a coordinating structure between different stages of production as well as facilitates the connection between different sectors. The goal is to create policies that promote sustainable public consumption of eco-friendly goods and services.

The following are the purposes of the National Action Plan on Sustainable Consumption and Production 2021 – 2030 targets. Different policy instruments are proposed to achieve these objectives:

- Promote resource efficiency and cleaner production through eco-innovation in the resource extraction and production stage.
- Support for greening the distribution systems and developing supply chains of environmentally friendly products and services.
- Provision of infrastructure supporting the consumers to make environmentally conscious decisions for promoting a sustainable lifestyle.
- Improve the competitiveness and market access of export-oriented enterprises/ manufacturers to participate in a global sustainable supply chain for key sustainable export products through restructuring export products towards sustainability.
- Improve the legal enforcement for environmental protection on imported scraps and waste and restructure imported products towards sustainability.
- Strengthen the capacity of ministries, provincial government, industry, research institutes, and formal education to implement SCP.
- Enhance the awareness of all actors in society to take action against SCP.
- Strengthen international cooperation in knowledge exchange and finance in SCP.

Product-policy frameworks - National Action Plan on Sustainable Consumption and Production 2021 – 2030.
Through the implementation of the NAP, 50% of urban solid waste and construction waste shall be recycled, reused, produced energy, or organic fertilizer by 2025 while it will increase to 80% by 2030. Around 75% of non-hazardous industrial solid waste in industrial parks will be collected for reusing and recycling by 2025, reaching 85% by 2030. Food waste reduction targets are aimed at a 30% reduction by 2025 and a 50% reduction by 2030. It is targeted that 50% of urban solid waste and construction waste will be recycled, reused, and produced as energy or organic fertilizer by 2025, reaching 80% by 2030.

3.6.1 Indicators

3.6.1.1 Water use

Water use per capita

The water use per capita in Vietnam decreased by almost 65.4 cubic meters per capita from 2010 to 2017. Overall, it decreased significantly with the rate of 9.4 cubic meters per capita annually from 2010 to 2017. In terms of percentage, total water use in Vietnam decreased by almost 6 percent from 2010 to 2017. The decrease noticed in water use per capita was probably due to the decoupling and improving the resource efficiency efforts of the policymakers. The time series of total water use of Vietnam from 2010 to 2017 is shown in **Figure 3-158**.

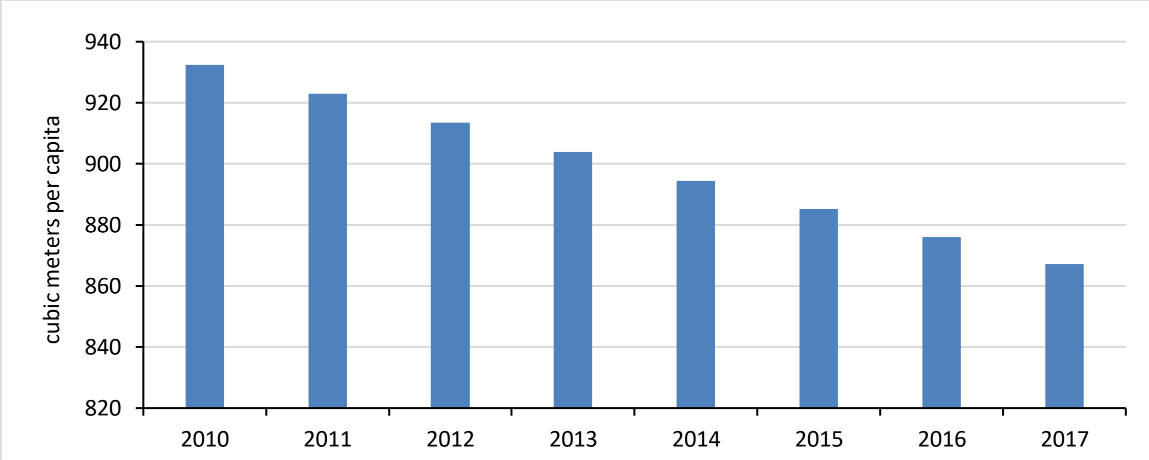


Figure 3-158 Total Water use per capita in Vietnam

Water use intensity

The total water use intensity of Vietnam remained constant from 2010 to 2017. In 2010, the total water use of Vietnam was 82 billion cubic meters. However, the economic activities and population increase significantly from 2010 to 2017. No increase in total water use even with the increase in GDP and population is possibly due to the decoupling and improving the resource efficiency efforts of the policymakers. The time series of total water use of Vietnam from 2010 to 2017 is shown in **Figure 3-159**.

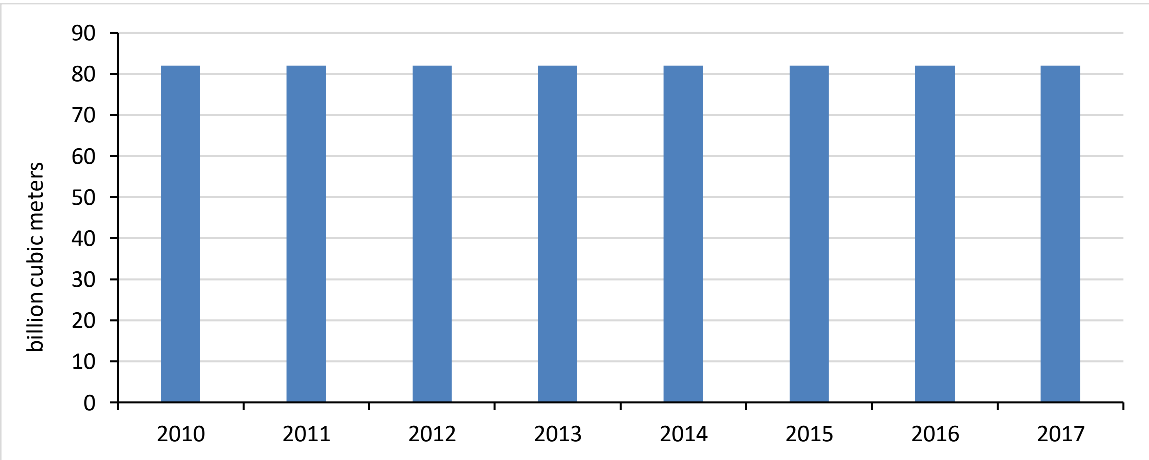


Figure 3-159 Total water use intensity of Vietnam

Water footprint in major sectors

Water footprint of agriculture sector

The water use footprint of the agriculture sector of Vietnam was decreasing from 2010 to 2018. In 2018, the total water use in Vietnam was 2.26 billion cubic meters per year. Overall, it decreased at the rate of 0.075 billion cubic meters per year from 2010 to 2018. The decrease in the water use footprint of the agriculture sector is possibly due to the change in land use in the agriculture sector or using efficient techniques for irrigation. The time series of water use footprint of the agriculture sector of Vietnam from 2010 to 2018 is shown in **Figure 3-160**.

Water footprint of food sector

Water use footprint of the food sector of Vietnam was showing decreasing trends. In 2010 the water use of the food sector in Vietnam was 0.12 billion cubic meters. Overall, it was decreasing at the rate of 0.005 billion cubic meters per year from 2010 to 2018. The decrease in the water use footprint of the food sector perhaps due to the utilization of efficient irrigation techniques during food production and processing shows the country's decoupling efforts. The time series of water use footprint in the food sector of Vietnam from 2010 to 2018 is shown in **Figure 3-160**.

Water footprint of construction sector

The water use footprint of the construction sector of Vietnam was increasing, with the rate of 0.016 billion cubic meters per year from 2010 to 2018. In 2018, the total water use in Vietnam was 0.35 billion cubic meters per year. The water use footprint of the construction sector of Vietnam was increasing, which is possibly due to an increase in economic activities and population growth of the country. It is possibly due to the decoupling efforts of the policymakers. The time series of water use in the construction sector of Vietnam from 2010 to 2018 is shown in **Figure 3-160**.

Water footprint of tourism sector

The water use footprint of the tourism sector of Vietnam was increasing, with a rate of 0.003 billion cubic meters per year from 2010 to 2018. In 2018, the total water use in Vietnam was 0.18 billion cubic meters per year. In 2013 and 2014, it decreased slightly. The overall increase in the water use footprint of the tourism sector of Vietnam is possibly due to its contribution to the tourism sector in the overall GDP of the country. The time series of water use in the tourism sector of Vietnam from 2010 to 2018 is shown in **Figure 3-160**.

Water footprint of transport sector

The water use in the transport sector of Vietnam was increasing, with the rate of 0.0014 billion cubic meters per year from 2010 to 2018. In 2018, the total water use in Vietnam was 0.03 billion cubic meters per year. The overall increase in water use in the transport sector of Vietnam is possibly due to an increase in economic activities and the population of the country. The time series of water use in the transport sector of Vietnam from 2010 to 2018 is shown in **Figure 3-160**.

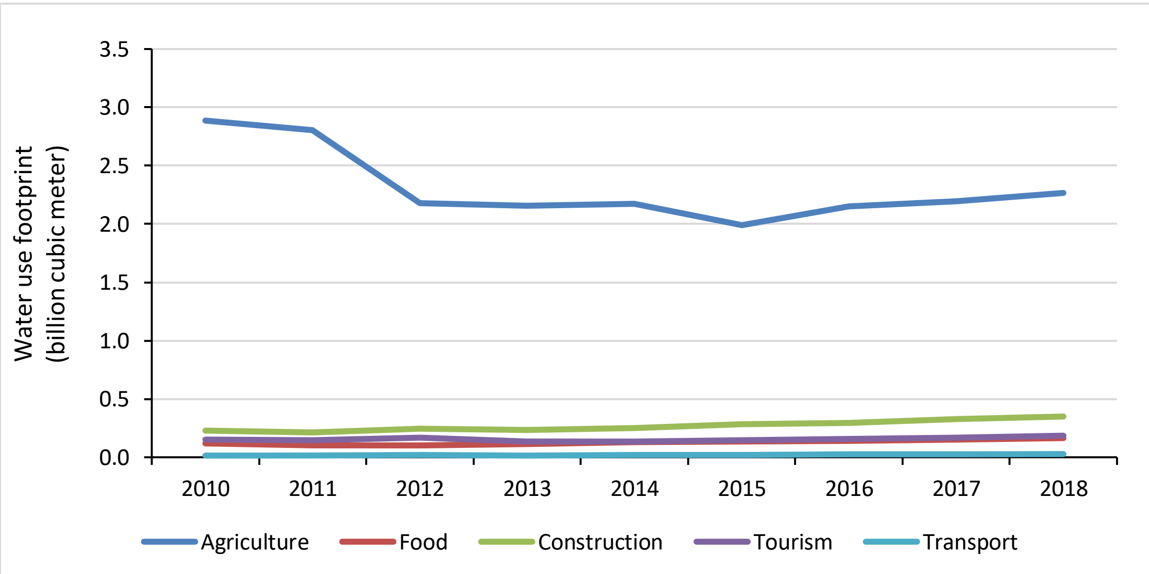


Figure 3-160 Water use footprint of five different sectors of Vietnam

3.6.1.2 Land use

Total land use

The total land use of Vietnam increased slightly from 1992 to 2015. In 1992 the total land use of Vietnam was 27.81 million hectares. Overall, it increased at the rate of 0.004 million hectares annually from 1992 to 2015. In terms of percentage, the total land use of Vietnam increased by almost 0.4 percent from 1992 to 2015. A slight decrease was noticed in the total land use of Vietnam due to deforestation. The significant increase in total land use of Vietnam is due to the rapid increase in population and economic growth which lead to the triggering of industrialization, robust urbanization, and agricultural land use; these all factors were responsible for the increase in total land use. However, at the same time, forest land covers decreases slightly. The time series of total land use of Vietnam from 1992 to 2015 is shown in **Figure 3-161**.

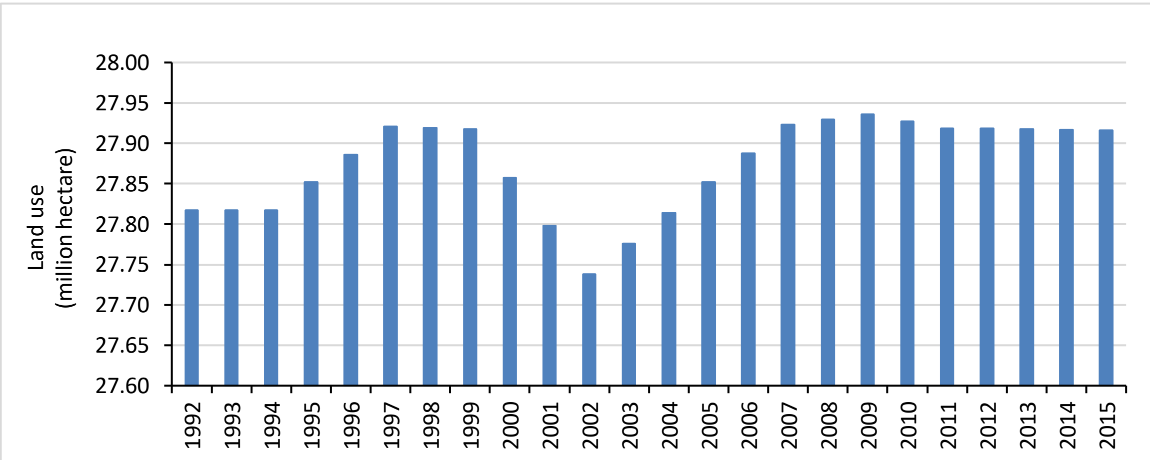


Figure 3-161 Total land use of Vietnam

Total land use per capita

The total land use per capita in Vietnam decreased from 1992 to 2015. In 1992, the total land use per capita in Vietnam was 0.39 square meters per capita annually, which decreased by 13 percent until 2015. Overall, it decreased at the rate of 0.004 square meters per capita from 1992 to 2015. The significant decrease in total land use per capita in Vietnam is probably due to rapid population growth while the land resources are the same as it was in 1992. The time series of total land use per capita in Vietnam from 1992 to 2015 is shown in **Figure 3-162**.

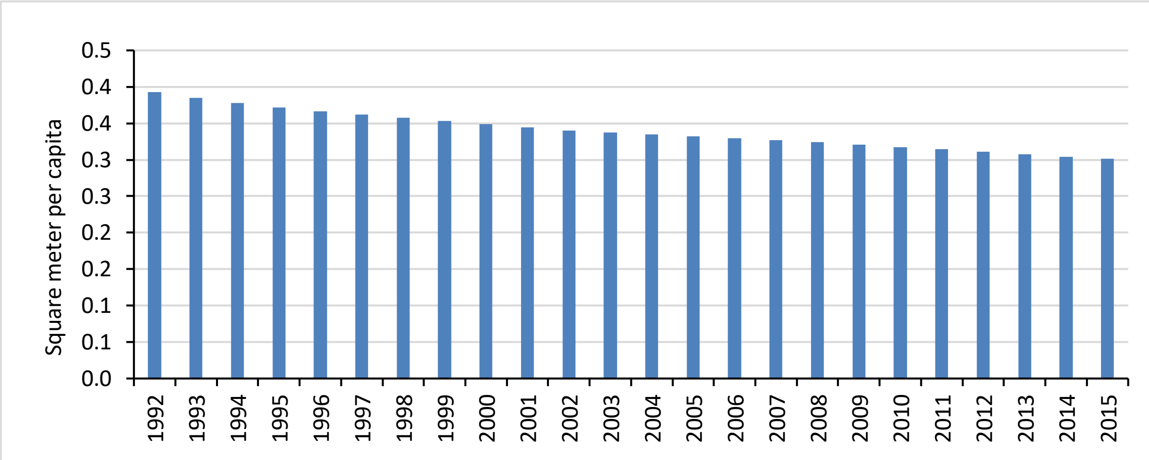


Figure 3-162 Total land use per capita of Vietnam

<u>Land use intensity</u>

The total land use intensity of Vietnam decreased significantly from 1992 to 2015. In 1992, the total land use intensity of Vietnam was 28.2 square meters per dollar annually, which has decreased by twenty folds until 2015. Overall, it decreased at the rate of 0.13 square meters per dollar from 1992 to 2015. The significant decrease in the total land use intensity of Vietnam is probably due to the rapid industrialization and robust urbanization as a result of the massive increase in GDP. The time series of total land use intensity of Vietnam from 1992 to 2015 is shown in **Figure 3-163**.

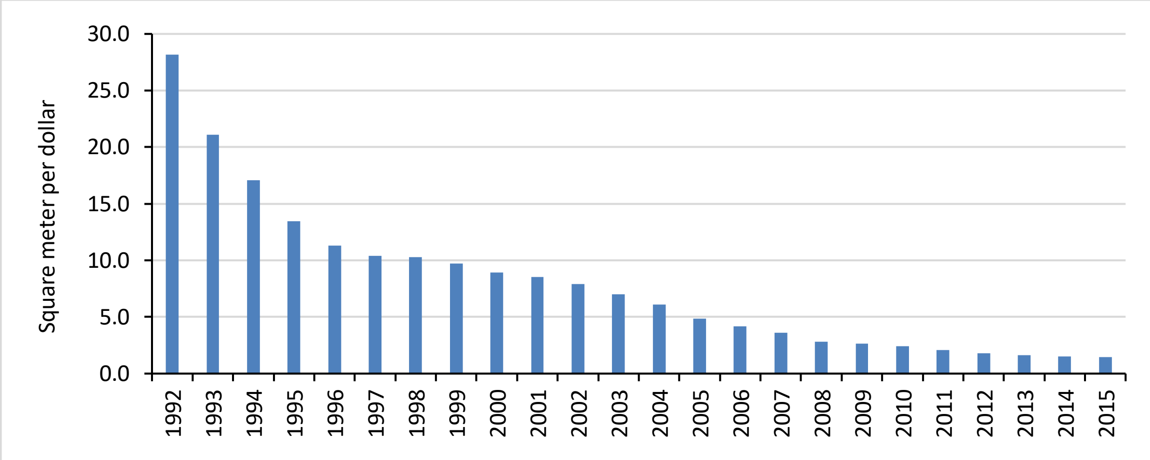


Figure 3-163 Total land use intensity of Vietnam

Land footprint in major sectors

Land footprint in agriculture sector

Land use footprint of the agriculture sector in Vietnam was showing an increase in trends from 1990 to 2018. In 1990 the land use of the agriculture sector in Vietnam was 1.88 million hectares that were increased by 6.93 million hectares by the end of 2018. The highest land use footprint of the agriculture sector was noticed in 2018 was 8.81 million hectares. Overall, it increased at the rate of 0.228 million hectares per year from 1990 to 2018. The increase in land use footprint of the agriculture sector is probably due to the increase in economic development and population expansion. The time series of land use footprint of the agriculture sector of Vietnam from 1990 to 2018 is shown in **Figure 3-164**.

Land footprint food sector

Land use in the food sector of Vietnam was showing slight increase trends from 1990 to 2018. In 1990 the land use of the food sector in Vietnam was 3.65 million hectares which were increased by 3.52 million hectares by the end of 2018. The highest land use in the food sector was noticed in 2018 was 7.17 million hectares. Overall, it was increasing at the rate of 0.103 million hectares per year from 1990 to 2018. The increase in land use in the food sector perhaps is due to the increase in economic development and population expansion. The time series of land use in the food sector of Vietnam land from 1990 to 2018 is shown in **Figure 3-164**.

Land footprint in construction sector

Land use footprint of the construction sector of Vietnam was showing fluctuating trends. In 1990 the land use of the construction sector in Thailand was 0.29 million hectares that were decreased by 0.15 million hectares by the end of 2018. The highest land use footprint of the construction sector was noticed in 2010 which was 0.58 million hectares. Overall, it was decreasing at the rate of 0.0085 million hectares per year from 1990 to 2018. The increase in the land use footprint of the construction sector is possibly due to the increase in economic development and population expansion. The time series of land use footprint of the construction sector of Vietnam land from 1990 to 2018 is shown in **Figure 3-164**.

Land footprint in transport sector

The land use footprint of the transport sector in Vietnam increased especially in the late 1990s then decreased up to 2018. In 1990 the land use footprint of the transport sector in Vietnam was 0.08 million hectares which were increased by 0.02 million hectares by the end of 2018. The highest land use footprint of the transport sector was noticed in 1999 which was 0.15 million hectares. Overall, it decreased at the rate of 0.0009 million hectares per year from 1990 to 2018. The time series of land use footprint of the transport sector of Vietnam land from 1990 to 2018 is shown in **Figure 3-164**.

Land footprint in tourism sector

Land use footprint of the tourism sector in Vietnam was showing an increase in the late 90s and earlier part of the first decade of this century. In 1990 the land use footprint of the tourism sector in Vietnam was 0.44 million hectares that were increased by 0.52 million hectares by the end of 2018. The highest land use footprint of the tourism sector was noticed in 2018 was 0.96 million hectares. Overall, it was increasing at the rate of 0.0075 million hectares per year from 1990 to 2018. The increase in land use footprint of the tourism sector is possibly due to the increase in economic development. The time series of land use footprint of the tourism sector of Vietnam land from 1990 to 2018 is shown in **Figure 3-164**.

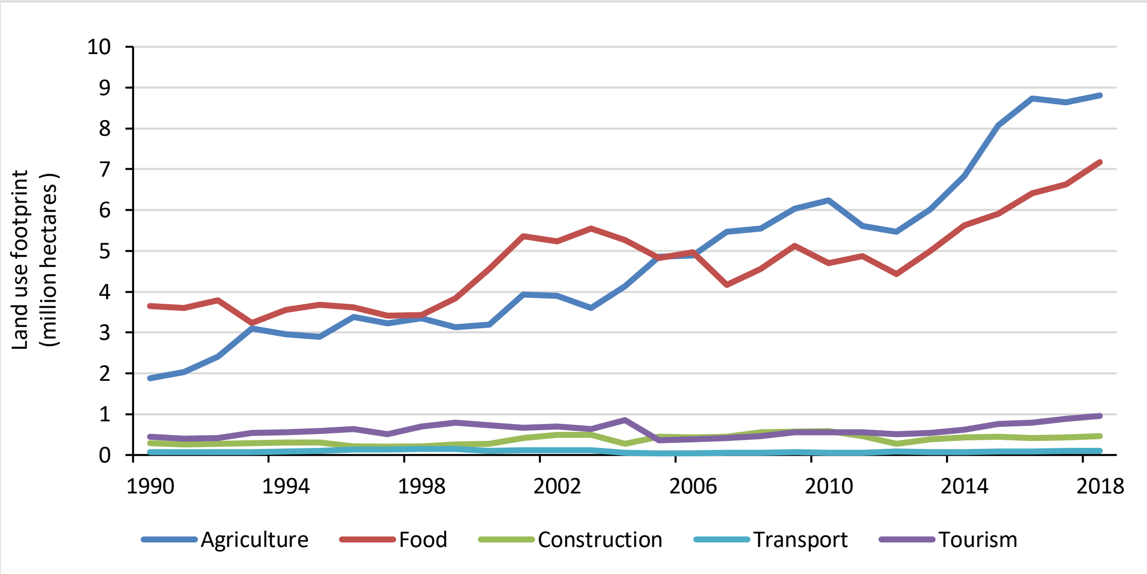


Figure 3-164 Land use footprint of five different sectors of Vietnam

3.6.1.3 Material use

As presented in **Figure 3-165**, the total DMC in the Viet Nam has increased from around 0.7 billion tonnes to around 0.9 billion tonnes in just seven years. During the concerned duration (2010-2017) a slight decline was noticed in the DMC in 2012, after which, a continuously increasing trend was experienced in the country. The overall increase in the country's DMC from 2010 to 2017 was 28%. The reason behind this increase in DMC of the country may be due to the country's massive industrial base that is continuing to grow rapidly. The most prominent industries in Viet Nam include clothing and textile, footwear, consumer goods (Consumer goods are anything that ends up being used by an end consumer), plastic and rubber, furniture, packaging, coffee, electronics, wooden goods, construction materials, iron and steel, and seafood.[258]

[258] https://www.cosmosourcing.com/blog/what-products-can-be-sourced-in-vietnam

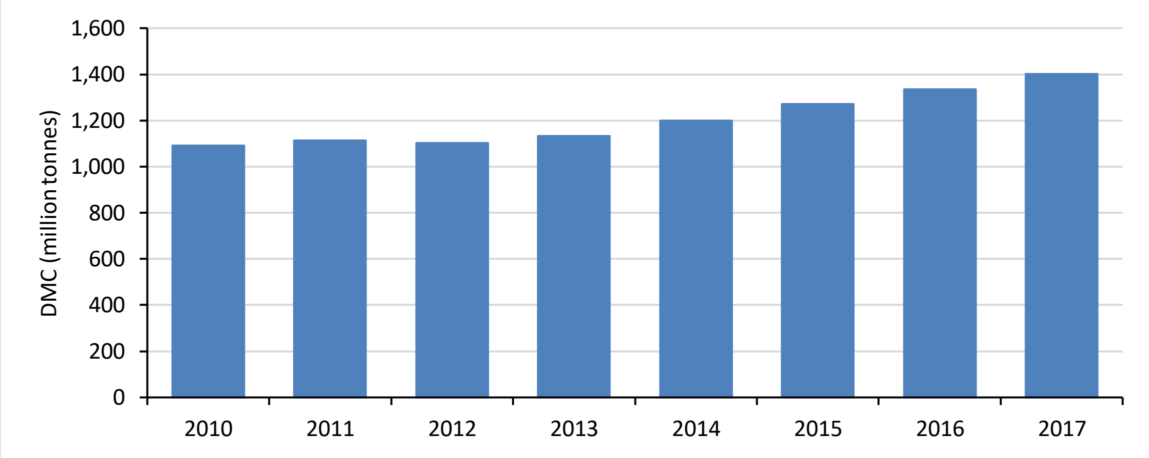


Figure 3-165 Domestic material consumption in Viet Nam (2010 – 2017)

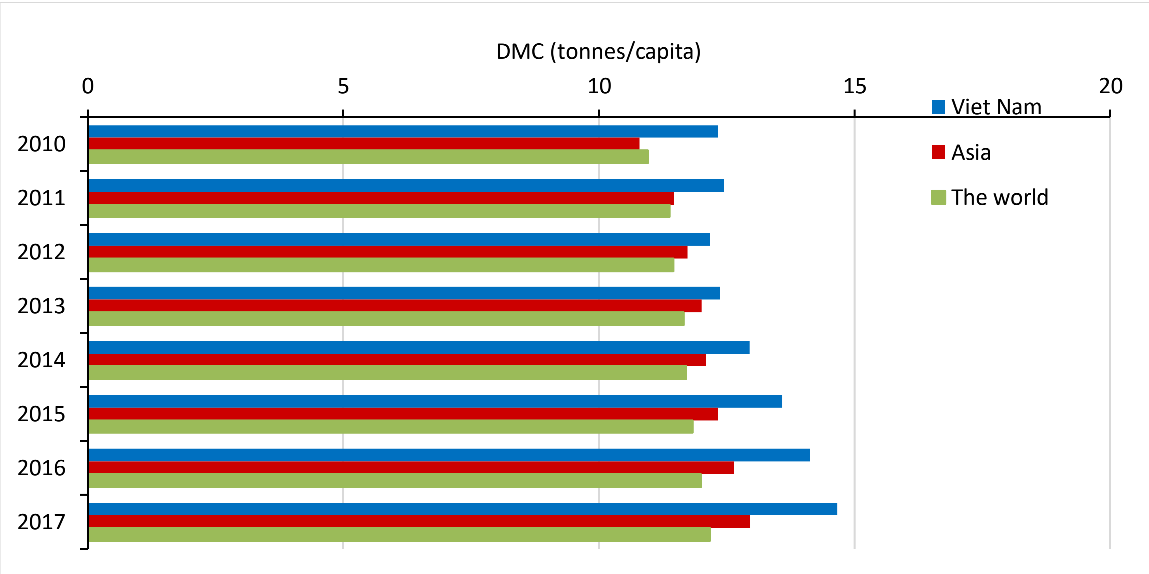


Figure 3-166 Per capita domestic material consumption in Viet Nam, Asia, and the World during 2010 – 2017

Figure 3-166 shows the per capita DMC of Viet Nam, Asia, and the World from 2010 to 2017. In 2010 the country's per capita DMC was 12.33 tonnes per capita which increased at a rate of 19% and reached 14.66 tonnes per capita in 2017. It can be seen from **Figure 3-166** that the country's per capita DMC increased is even higher compared to the per capita DMC in Asia and the World. The reason may be the slow growth in the country's population as compared to the growth in DMC. From 2010 to 2017, the country's total DMC increased at a rate of 28%, while the population growth rate was only 7.5%.

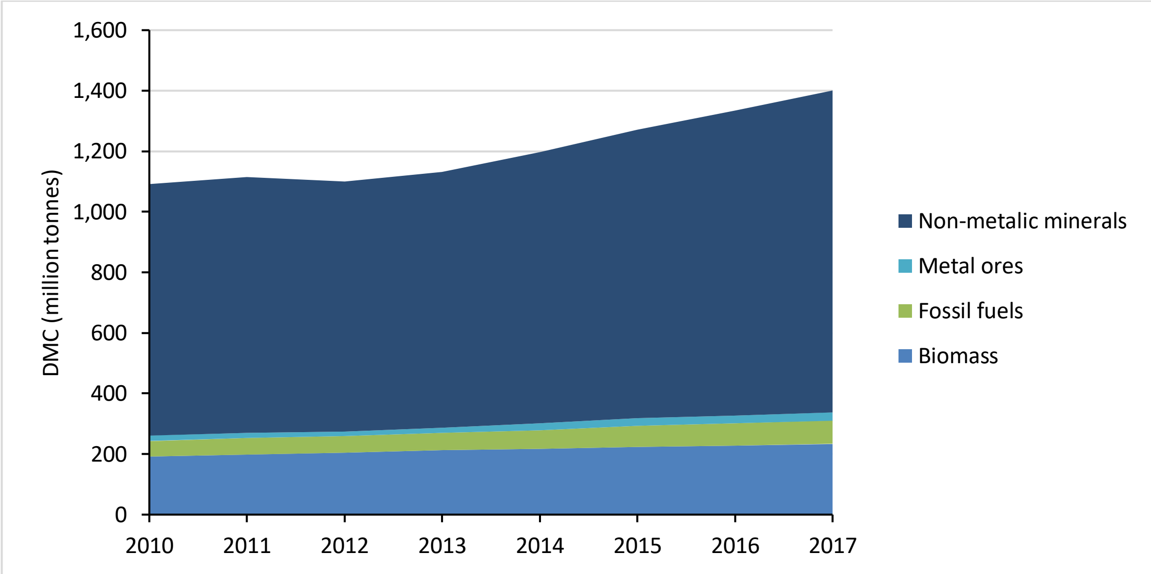


Figure 3-167 Domestic material consumption by material category in Viet Nam (2010 – 2017)

Figure 3-167 presents the category-wise DMC in Viet Nam. It can be seen that different material categories show an increasing trend. From 2010 to 2017, the average annual growth in DMC of biomass, fossil fuels, metal ores, and non-metal minerals has increased at a rate of 0.456%, 0.410%, 0.276%, and 0.681%, respectively. It can be observed that the percentage growth in DMC of non-metallic minerals is highest among all four material categories, followed by biomass, fossil fuels, and metal ores, respectively. Moreover, non-metallic minerals also share the most in the country's total DMC, in absolute terms. The total non-metallic minerals consumption of the country was 192 million tonnes that were increased by a rate of 28% and reached more than 1 billion tonnes in 2017. On the other hand, the DMC of biomass, fossil fuels, and metal ores was 192, 51, and 18 million tonnes which were increased by a rate of 22%, 52%, and 51% and reached 233, 78, and 27 million tonnes in 2017, respectively. These statistics indicate the strong momentum of Viet Nam's economic drivers viz, domestic demand and export-oriented manufacturing.

Material use by major sectors

Vietnam has been a model of progress. Since the beginning of Đổi Mới in 1986, economic reforms, along with favorable global trends, have enabled Vietnam to transition from one of the world's poorest countries to a middle-income economy during the last two decades. Between 2002 and 2020, GDP per capita climbed 2.7 times, reaching about $US 2,800. Over the same period, poverty rates ($US 1.90/day) fell drastically from over 32% in 2011 to under 2%. With growing living standards, health outcomes have improved. Access to infrastructural services has greatly improved, as has access to clean water in rural regions, which has grown from 17% in 1993 to 70% in 2016. (it is above 95 percent for urban areas).[259] Vietnam, on the other hand, is one of the nations with vast natural resources with great exploitation potential. However, the quality of the environment and natural resources is deteriorating significantly as a result of poor management, low and outdated technology, excessive exploitation of natural resources, the effects of climate change and sea-level rise, as well as a lack of public awareness about environmental protection.[260] **Figure 3-168** presents the material used in six major sectors in the country.

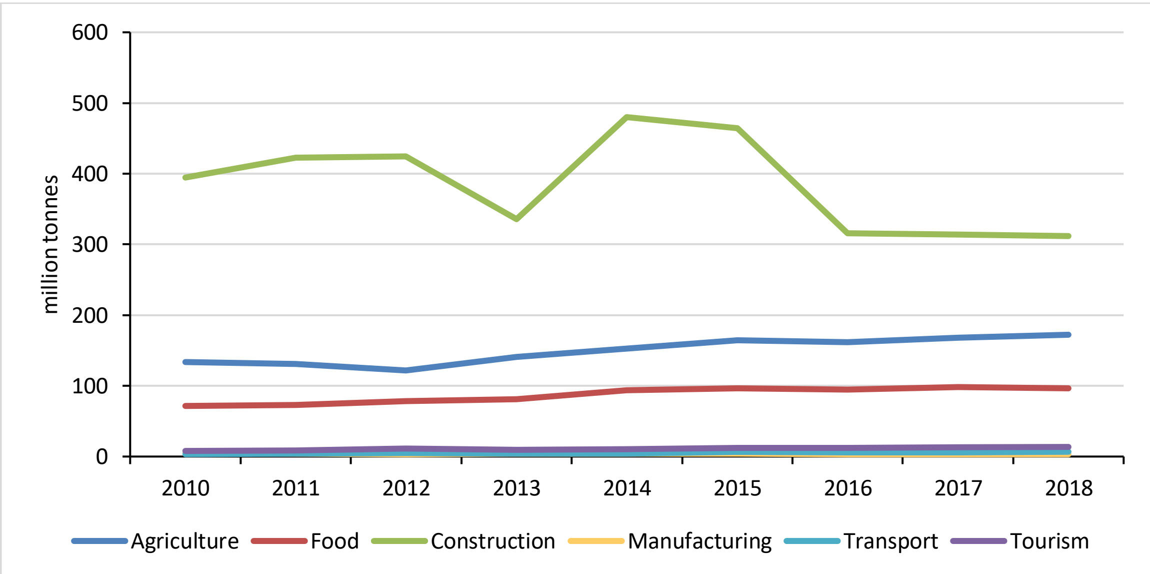


Figure 3-168 Sector-wise material footprint of Viet Nam (2010-2018)

It can be seen from **Figure 3-168** that the construction sector has the highest material consumption though the sector has experienced some ups and downs during the considered time series, but the overall material consumption has decreased by more than 21% and

[259] https://www.worldbank.org/en/country/vietnam/overview#1
[260] Thi Thu Ha, C. 2014. State of the environment and natural resources in Vietnam. Journal of Vietnam Environment. 6 (1), pp. 1-3.

reached 312 million tonnes in 2018 from 395 million tonnes in 2010. On the other hand, the agriculture sector is the second largest sector in the country regarding material consumption. However, the material consumption of the agriculture sector is almost half as compared to the construction sector, but it is continuously increasing at a steady pace. The material consumption of the agriculture sector was 134 million tonnes in 2010 which has increased to more than 172 million tonnes in 2018. The third-largest sector regarding material consumption is the food sector in Viet Nam. However, the percentage growth of the food sector was around 35% which was higher as compared to the percentage growth in the agriculture sector. The sectors including transport, tourism, and manufacturing are the bottom three sectors, respectively.

Material Intensity

Figure 3-169 illustrates the comparison of material intensity (kg per $) between Viet Nam, Asia, and the world. The material intensity of the world remained almost constant from 2010 to 2017. On the other hand, the material intensity of Viet Nam and the overall Asian region was 5.5 times and 2.4 times higher than the overall world in 2017, respectively. There was a tremendous improvement in the material intensity of the country. Between 2010 to 2012 the country's material intensity experienced a sharp fall after that it continued to decrease steadily from 2013 to 2017. However, the material Intensity of Viet Nam is much higher when compared with the overall Asian region from 2010 to 2017. The reason behind the low efficiency of the country's production and consumption system may be the dramatic increase in access to infrastructure services. As of 2016, 99% of the population used electricity as their main source of lighting, up from just 14% in 1993. Access to clean water in rural areas has also improved, up from 17% in 1993 to 70% in 2016, and is above 95% for urban areas.[261]

[261] http://web.worldbank.org/archive/website01363/WEB/0__-10737.HTM

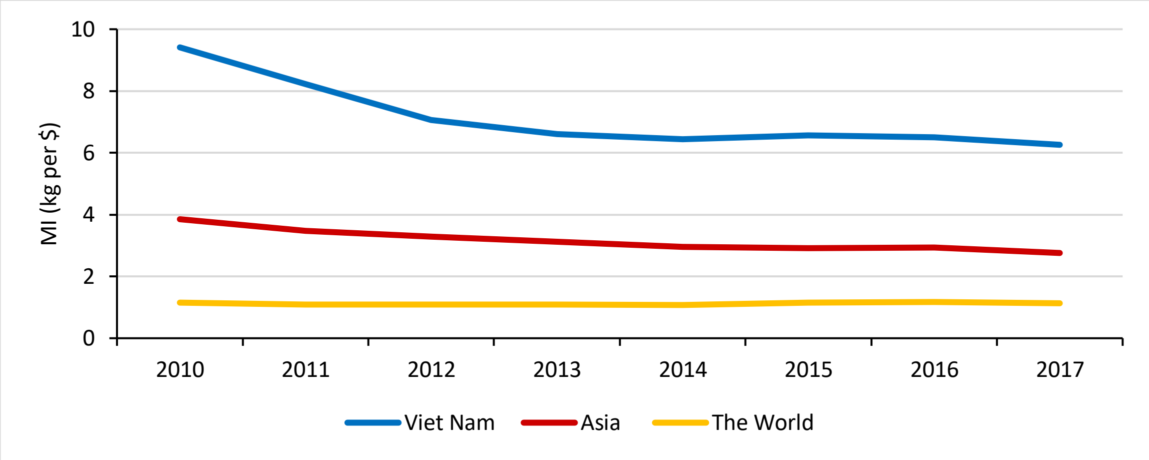


Figure 3-169 Material intensity for Viet Nam, Asia, and the World (2010 – 2017)

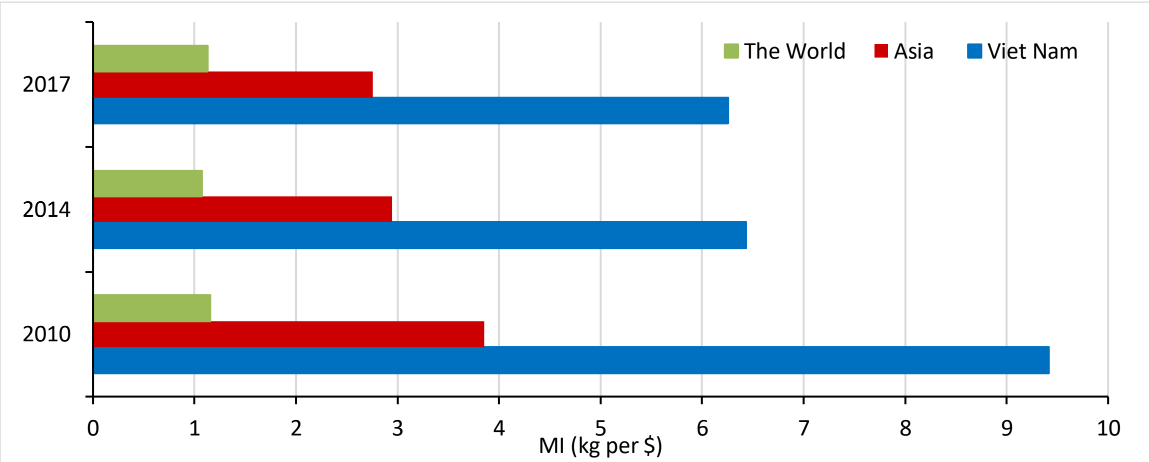


Figure 3-170 Material intensity of Viet Nam, Asia, and the World (2010, 2014, 2017)

Figure 3-170 compares the material intensity of Viet Nam with the material intensity of Asia as well as the whole world. It can be seen that in 2010, Viet Nam's material intensity was around 4 times and more than 8 times higher as compared to overall Asia and the World, respectively. Despite a prominent change in the country's material intensity, it remained higher as compared to the overall Asian region and the world in 2014 and 2017. The reason behind this huge gap between the material intensity of Viet Nam Vs Asian region and the world may be country's exports are increasingly dependent on imports of intermediate inputs and raw materials.[262]

262 https://www.ide.go.jp/library/English/Publish/Reports/Brc/pdf/05_chapter10.pdf

Material footprint of consumption

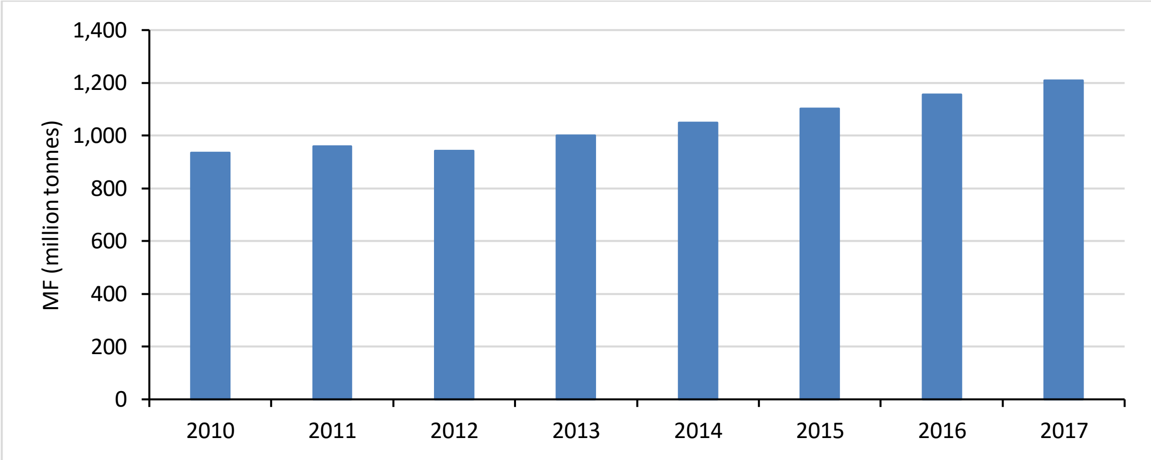


Figure 3-171 Material footprint of consumption in Viet Nam (2010 – 2017)

Figure 3-171 shows the material footprint of consumption of the Viet Nam. It can be seen that the material footprint of consumption has increased in Viet Nam from 2010 to 2017. In 2010 the total material footprint of Viet Nam was less than 0.94 billion tonnes that were increased in 2017 and reached a total of more than 1.2 billion tonnes. The country experienced an overall increase of more than 29% in the domestic material footprint of consumption. This rapid growth in Viet Nam's material footprint of consumption also reflects the immense growth of GDP in the country. In 2010 the total GDP of Viet Nam was $US 116 billion that was increased by 93% in 2017 and reached a total of $US 224 billion. The increase in both the material footprint of consumption and GDP of Viet Nam shows an immense increase in production activities in the country. The GDP growth rate was 6.8% in 2017 which made Viet Nam one of the fastest-growing economies in the world. A substantial increase in industrial production was the major driver of the economy's excellent growth in 2017.[263]

[263] https://ihsmarkit.com/research-analysis/15012018-manufacturing-sector-leads-strong-growth-vietnams-gdp.html#:~:text=Central%20to%20the%20impressive%20growth,survey%2C%20compiled%20by%20IHS%20Markit.

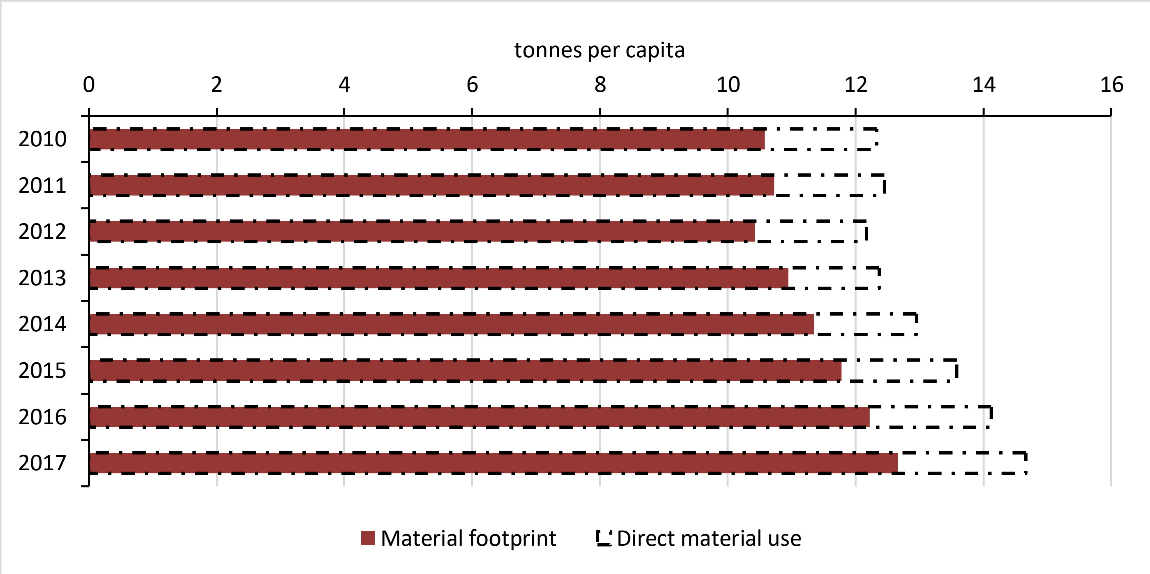


Figure 3-172 Material footprint per capita compared to domestic material consumption per capita in Viet Nam (2010-2017)

Figure 3-172 compares the material footprint per capita with the DMC per capita of the Viet Nam from 2010 to 2017. It can be seen from Figure 22 that Viet Nam has a higher DMC per capita as compared to material footprint per capita from 2010 to 2017. This is because the country's growth in exports of manufactured goods has been commendable. The total exports of the country were around $US 24 billion in 2006 which increased to more than $US 149 billion in 2016.

3.6.1.4 Energy use

Viet Nam is heavily reliant on coal imports as coal-based power technologies have been implanted to fulfill rapidly rising energy needs. As a result, the country faces major risks to its energy security. On the other hand, large rivers especially the Mekong is playing a key role to fulfil the energy demand. In 2020, five percent of Viet Nam's power generated from non-hydro renewable energy sources including wind and solar.[264] The three primary sectors that utilize the maximum energy are industry, residential, and transportation as shown in **Figure 3-173**. The energy demand in the industrial sector increased significantly after 2010, showing

[264] EIA. (2021). Vietnam's latest power development plan focuses on expanding renewable sources. Available at: https://www.eia.gov/todayinenergy/detail.php?id=48176

the rapid economic growth in the country. However, the trend for energy consumption by the industrial sector showed stagnant since 2015. On the other hand, a sharp decline can be observed in the energy consumption of the residential sector after 2010. Between 1990 and 2019, the agriculture/forestry and services sectors didn't change significantly.

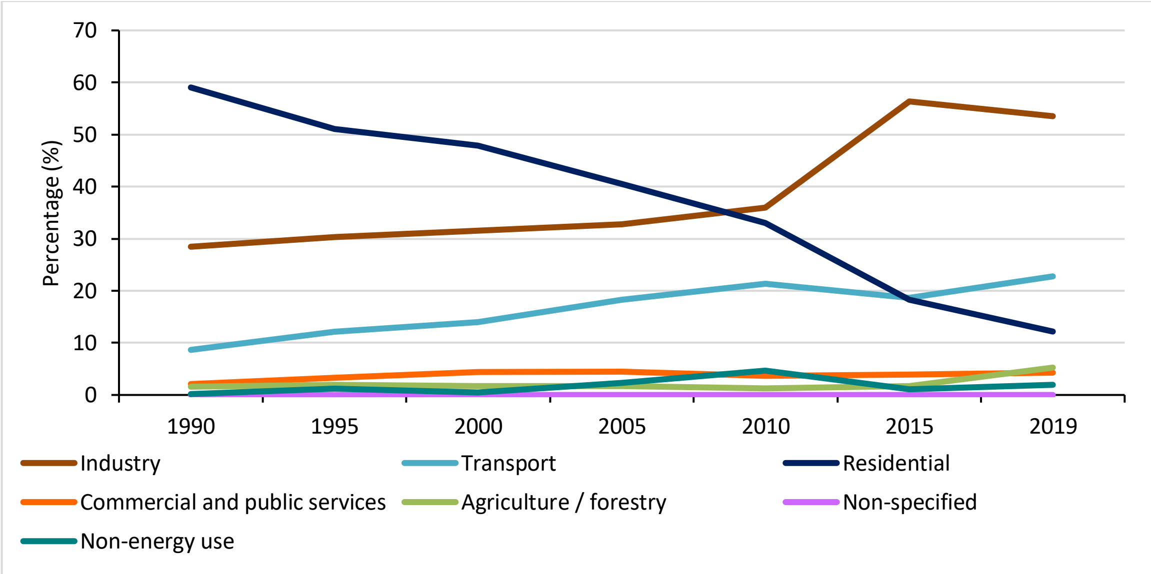


Figure 3-173 Sectoral share in total final energy consumption in Viet Nam (1990-2019) [265]

[265] IEA. (2022). International Energy Agency. Retrieved from https://www.iea.org/data-and-statistics/data-browser?country=WORLD&fuel=Energy%20consumption&indicator=TFCShareBySector

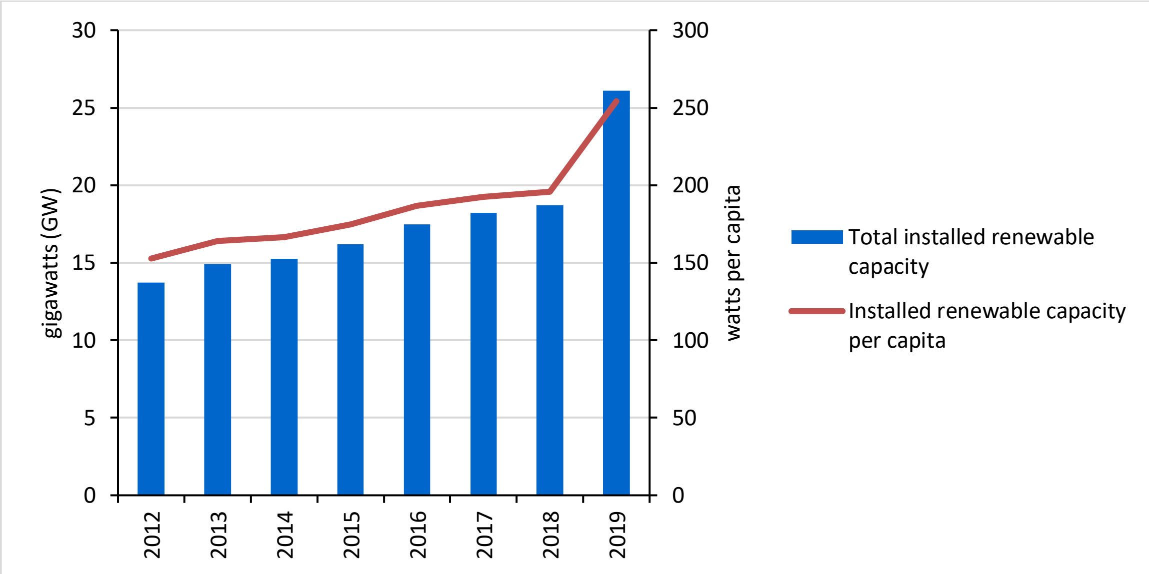


Figure 3-174 Installed renewable electricity-generating capacity in Viet Nam (2012-2019) [266,267]

The government has promoted the growth of renewable energy, particularly wind and solar power, throughout the country and in all areas of the economy. The installed power generation capacity by renewables has increased from 13.7 gigawatts to 26 gigawatts from 2012 to 2019. Among the many company activities, medium- and small-sized firms have spent the most on renewable energy development. On the other hand, a sharp decline can be observed in the energy consumption of the residential sector. As biomass is mainly used for cooking in the residential sector. However, this ratio is significantly dropping as commercial fuels with higher efficiency are replacing biomass fuels. Higher living standards will result from economic growth, hastening the switch from biomass to modern fuels. Furthermore, thousands of homes have invested in rooftop solar systems without any financial or technical complications due to the strong will of the government. This demonstrates the successful execution of policies aimed at stimulating investment in the expansion of the electricity industry.

[266] UNEP. (2022). The United Nations Environment Programme. Available at: https://wesr.unep.org/downloader
[267] IRENA (2022).RENEWABLE CAPACITY STATISTICS 2022. *The International Renewable Energy Agency (IRENA)*. Available at: https://www.irena.org/IRENADocuments/Statistical_Profiles/Asia/China_Asia_RE_SP.pdf. [Accessed on April 2022]

The major policy interventions by the government of Viet Nam include 1) Accelerated depreciation tax relief for renewable energy projects in force since 2013; 2) Decision on support mechanisms for the development of biomass power projects in Vietnam (biomass feed-in tariff) in 2014; 3) Decision on support mechanisms for the development of waste-to-energy power projects in Vietnam (feed-in tariff) in 2014; 4) National Power Development Plan 7 (PDPD7 – revised) in 2016; 5) Vietnam Renewable Energy Development Strategy 2016-2030 with outlook until 2050 (REDS) in 2016[268].

Energy Intensity

The energy sector in Vietnam is seeking innovative solutions to address energy and environmental challenges. Scaling up energy efficiency is the most cost-effective way to fulfill numerous goals at once: satisfying energy demand, mitigating pollution, and increasing environmental sustainability while simultaneously improving industry competitiveness.

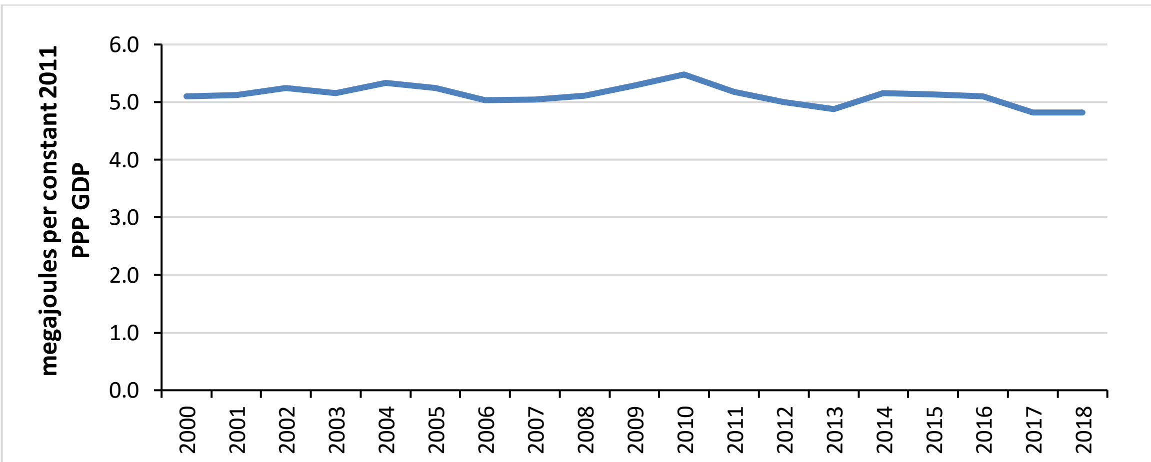


Figure 3-175 Energy intensity of Viet Nam (2000-2018)

The energy intensity of Viet Nam has been fluctuating substantially during the past two decades. However, after hitting the highest value (i.e., 5.5 megajoules per constant 2011 PPP GDP) in 2010, there was a sharp decline until 2013; then, again it tended to fluctuate through the 2013 - 2018 period ending at 4.8 megajoules per constant 2011 PPP GDP in 2018 as shown

[268] Policy database (2022). Policy in Viet Nam. *International Energy Agency (IEA) Policies Database.* Available at: https://www.iea.org/policies?qs=Viet%20Nam&country=Viet%20Nam. [Accessed on April 2022]

in **Figure 3-175**. On the other hand, according to the World Bank's Low Carbon Study, if significant demand-side energy efficiency measures are made, Viet Nam could save up to 11 GW by 2030.[269] More specifically, improvements in energy efficiency in the cement, steel, porcelain, cold-chain, frozen, and consumer products industries have the potential to save more than 20% of total energy use.[270]

3.6.1.5 Agricultural productivity

Vietnam is the third most populous country in Southeast Asia, behind Indonesia and the Philippines, with a population of over 90 million people. Agriculture accounts for 23% of GDP in Vietnam. Agricultural activities employ around 62 percent of the Vietnamese labor population.[271] As demonstrated in **Figure 3-176**, the agricultural sector in Vietnam has achieved great strides in terms of productivity and production. However, this has resulted in resource inefficiencies and unsustainable practices, as well as losses in farmer welfare and food of low quality and safety. To address these issues, Hanoi has implemented several agricultural policy changes, including an agricultural restructuring program, a good agricultural practice (GAP) and certification program, a food safety program, value chain development, land consolidation, and automation. In the domains of agriculture and water, Vietnam and the Netherlands have close connections. The Agriculture and Food Security Strategic Partnership Arrangement, agreed upon in 2014, serves as an overarching umbrella framework for all existing and emerging areas of collaboration in agriculture and food security in the broadest sense.

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269 https://www.worldbank.org/en/news/press-release/2021/03/08/wb-gcf-provide-vietnam-with-us863-million-to-spur-energy-efficiency-investments

270 https://www.trade.gov/market-intelligence/vietnam-energy-efficiency

271 Dang, K. S., Nguyen, N. Q., Pham, Q. T., Truong, T. T. T., & Beresford, M. (2006). Policy reform and the transformation of Vietnamese agriculture. In Rapid growth of selected asian economies: Lessons and implications for agriculture and food security. Policy Assistance Series 1/3, FAO Regional Office for Asia and the Pacific.Last accessed April 1st, 2020. http://www.fao.org/3/ag089e/AG089E08.htm#ch3

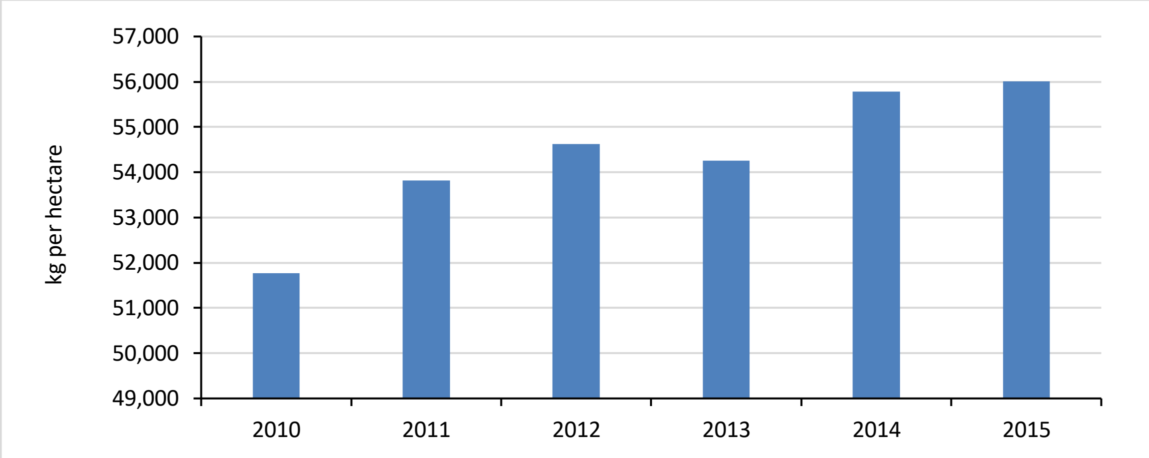

Figure 3-176 Agricultural productivity in Vietnam (2010 - 2015)

3.6.1.6 Greenhouse gas emissions

Vietnam's fast economic expansion and rising energy consumption have resulted in an exponential increase in GHG emissions, with the country ranking second in Southeast Asia for emissions in 2019. The total GHG emissions of Vietnam have grown 937% from 1991 to 2012[272]; these emissions have generally grown since 2010 as shown in **Figure 3-177**.

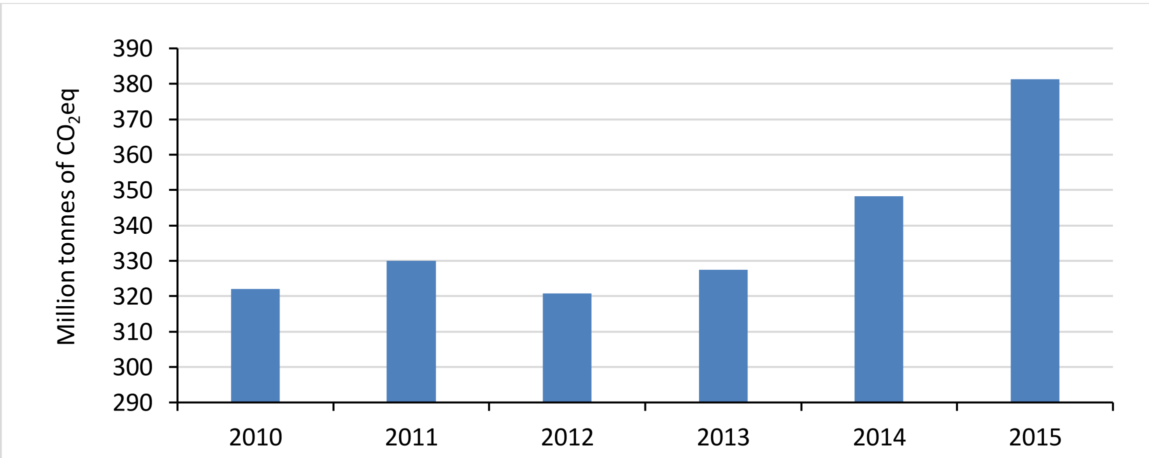

Figure 3-177 Viet Nam's total GHG emissions (2010 - 2015)

Energy and agricultural emissions account for 89 percent of total GHG emissions in Vietnam. The new domestic GHG emission trading scheme authorized by Vietnam's updated Law on

[272] *Greenhouse Gas (GHG) Emissions by Sector*. (n.d.). https://www.climatelinks.org/sites/default/files/asset/document/Vietnam%20Fact%20Sheet%20-%20rev%2010%2007%2016_Final.pdf

Environmental Protection seeks to construct a carbon pricing mechanism that penalizes GHG emitters based on the principle of "polluter pays" to satisfy the country's development and climate change goals.[273] In addition, the Vietnamese Ministry of Natural Resources and Environment, in collaboration with the United Nations Development Programme (UNDP) and the Intergovernmental Panel on Climate Change (IPCC), has agreed to a new IPCC Special Report on the effects of global warming. Vietnam has also produced a Plan for the Implementation of the Paris Climate Change Agreement, with an emphasis on executing its Nationally Determined Contributions (NDC).[274]

Greenhouse gas intensity (2010 - 2015)

The "National Target Programme on Energy Efficiency" and the Law on "Economical and Efficient Use of Energy" are two policies developed by the government of Vietnam. According to Vietnam's Intended Nationally Determined Contribution (INDC), the country targets to cut GHG emissions by 8% below the Business as Usual (BAU) scenario by 2030 using local resources.[275] With international cooperation, the INDC believes that this aim might be raised to 25%. Total emissions in Vietnam have surged sevenfold, and per capita emissions have more than quadrupled, while the carbon intensity of GDP has increased by 78%. As illustrated in **Figure 3-178**, the Vietnamese government has developed several national policies to assist lower the carbon intensity of growth. Climate change mitigation and adaptation strategies were created as part of the 2008 National Target Program to Respond to Climate Change. As a result, the 2011 National Climate Change Strategy emphasizes enhanced use of modern energy technology, higher energy efficiency, increased use of public transportation and cleaner transportation fuels, as well as afforestation. The 2012 Green Growth Strategy includes 66 initiatives to reduce GHG emissions by up to 2% yearly over the long term. The country has also committed to increasing renewable energy generation in its 8th Socio-economic Development Plan (SEDP) for 2016–2020.

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[273] Carbon Pricing Aids Vietnam's Efforts Towards Decarbonization. (n.d.). World Bank. https://www.worldbank.org/en/news/feature/2021/11/11/carbon-pricing-aids-vietnam-s-efforts-towards-decarbonization
[274] *IPCC presents findings of the Special Report on Global Warming of 1.5°C at event to discuss Viet Nam's response to climate change — IPCC*. (2019). Ipcc.ch; IPCC. https://www.ipcc.ch/2018/10/10/ipcc-presents-findings-of-the-special-report-on-global-warming-of-1-5c-at-event-to-discuss-viet-nams-response-to-climate-change/
[275] *Pathways to Low-Carbon Development for Viet Nam*. (2017). https://doi.org/10.22617/tcs179192-2

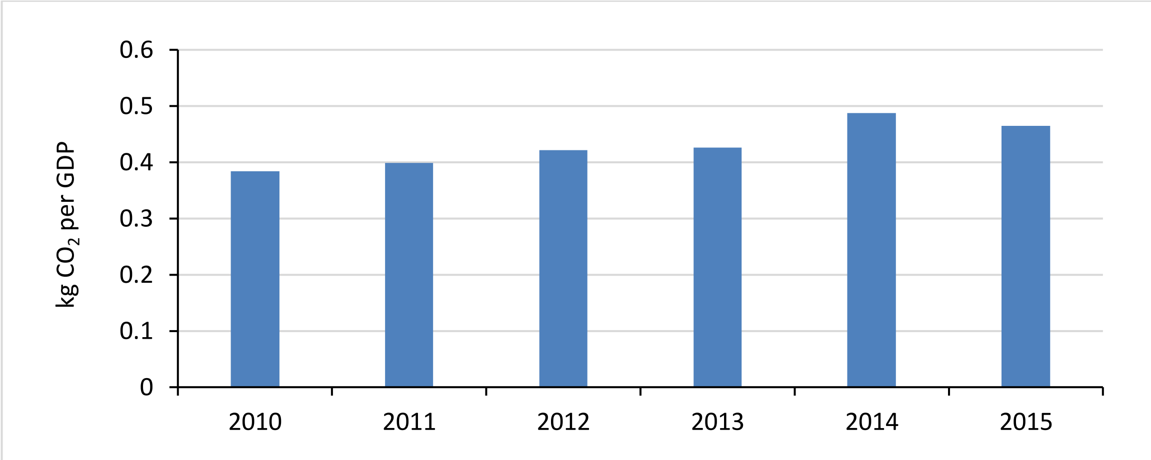

Figure 3-178 GHG intensity of Vietnam (2010 - 2015)

Greenhouse gas from major sectors

Greenhouse gas from energy use

Energy and energy security are critical for long-term economic growth, with fossil fuels (coal, oil, and gas) serving as the primary sources. In Vietnam, the share of fossil fuel usage in total energy consumption has risen quickly, from 27.6 percent in 1990 to 70 percent in 2016.[276] During the period 1990 to 2016, total primary energy consumption in Vietnam increased at a pace of 6.1 percent per year, with the industrial, residential, and transportation sectors accounting for almost 93 percent of total end-use consumption.[276,277] As illustrated in **Figure 3-179**, the rapid expansion of fossil fuel consumption has been linked to a considerable increase in emissions. GHGs emissions are the results of the burning of fossil fuels (coal, oil, and gases).

[276] International Energy Agency (IEA). (2018). Key world energy statistics. Available at https://www.oecd-ilibrary.org/docserver/key_energ_stat-2018.
[277] BP (British Petroleum). (2018). Statistical review of world energy. Available at https://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html.

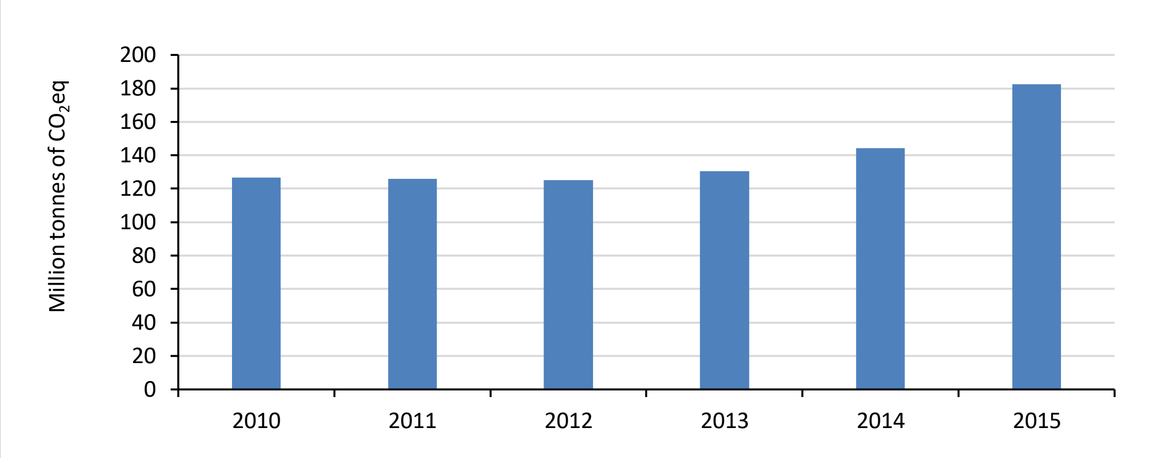

Figure 3-179 GHG from energy use (2010 - 2015)

Greenhouse gas from agriculture

Agriculture is a major contributor to global greenhouse gas (GHG) emissions. In 2010, agricultural GHG emissions in Vietnam exceeded 60 Mt CO_2eq, accounting for around 20% of total country emissions (**Figure 3-180**). Expanded or more intense use of land, as well as relatively extensive use of fertilizer and other agrochemicals, have contributed significantly to Vietnam's agricultural growth. As a result, some of Vietnam's agricultural achievements have come at the price of the environment. As a result, human, natural, and chemical aspects of production have played a significant role in Vietnam's agricultural development. Agriculture-related emission reduction commitments have been specified for the country's Nationally Determined Contributions (NDCs) in the Paris Agreement. Methods for going from intent to establishing and implementing agricultural NDC action plans, on the other hand, have not been well documented. Concrete, actionable, and replicable methods for understanding and measuring mitigation scenarios are required for planning and targeting investment strategies for national governments to move beyond "business as usual" scenarios and meet their NDC commitments with financial and implementation support from international organizations.

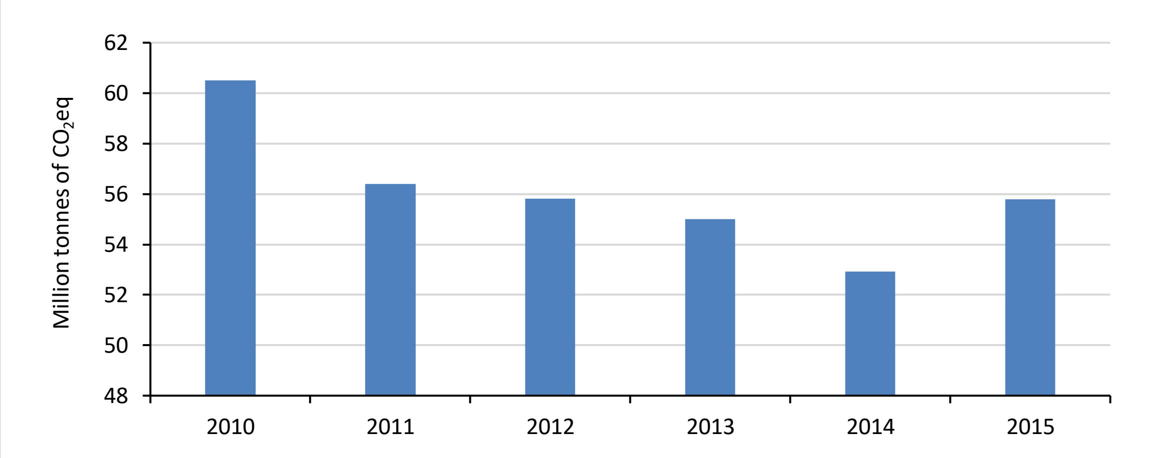

Figure 3-180 GHG from agriculture (2010 - 2015)

3.6.1.7 Material use and HDI

In this section of the report, we examined the relationship between the Human Development Index (HDI) – a measure of human development - and the growth in material use in Viet Nam from 2010 to 2017. **Figure 3-181** presents the relationship between the human development index (HDI) versus material use (DMC per capita), and material footprint (MF per capita) for Viet Nam from 2010 to 2017.

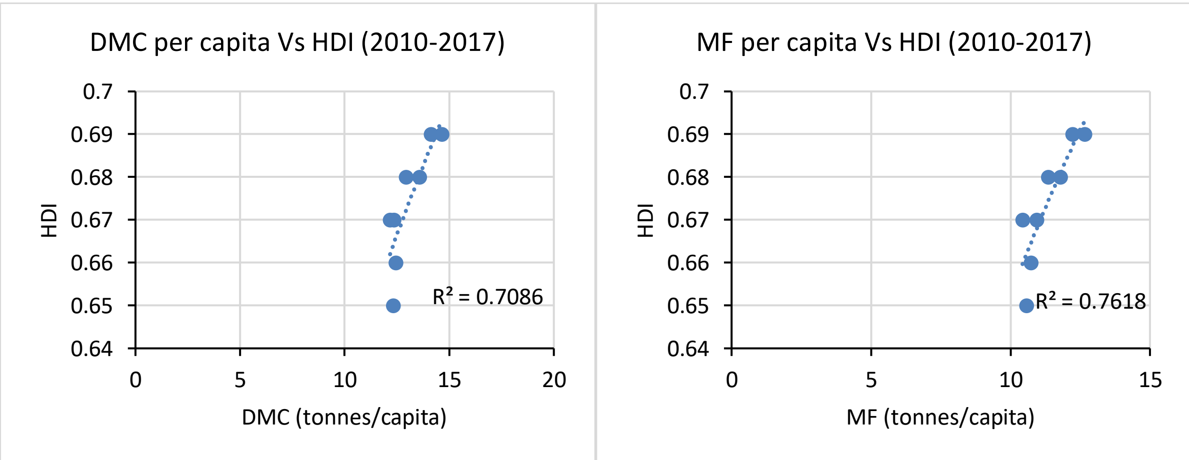

Figure 3-181 The relationship between material use (DMC per capita), and material footprint (MF per capita) versus the human development index (HDI) for Viet Nam (2010-2017).

Figure 3-181 presents the relationship between DMC and HDI, and the relationship between the material footprint of consumption and HDI in Viet Nam from 2010 to 2017. It can be seen from Figure 64 that the correlation between DMC and HDI is slightly weaker as compared to material footprint as the value of correlation coefficient "*r*" between DMC and HDI, and material footprint and HDI was 0.8392 and 0.8708, respectively, from 2010 to 2017. It may be because the manufacturing industry in the country is growing very rapidly. In the period 2006-2016, the country rose to 27 places in the world rankings, from 69th to 42nd. This was by far the largest jump among ASEAN countries. The disparity between the region's top five countries (Singapore, Malaysia, Thailand, Indonesia, and the Philippines). Furthermore, from $US 262 in 2006 to $US 759 in 2011, and $US 1,603 in 2016, Viet Nam's export per capita surged sixfold. As a result, the worldwide weight of Viet Nam's total value of manufactured exports has climbed, from 0.25 percent in 2006 to 0.53 percent in 2011, and 1.29 percent in 2016.[278]

3.6.1.8 Economic growth

In this section, GDP is used as a complementary indicator to show how overall production activities provide a different perspective on domestic material consumption and material footprint in Viet Nam. The time series covered is from 2010 to 2017. **Figure 3-182** shows the relationship between the GDP per capita (USD/capita) versus material use (DMC per capita), and material footprint (MF per capita) for Viet Nam from 2010 to 2017.

[278] https://www.unido.org/sites/default/files/files/2020-03/Final%20Vietnam_White_Paper_2019.pdf

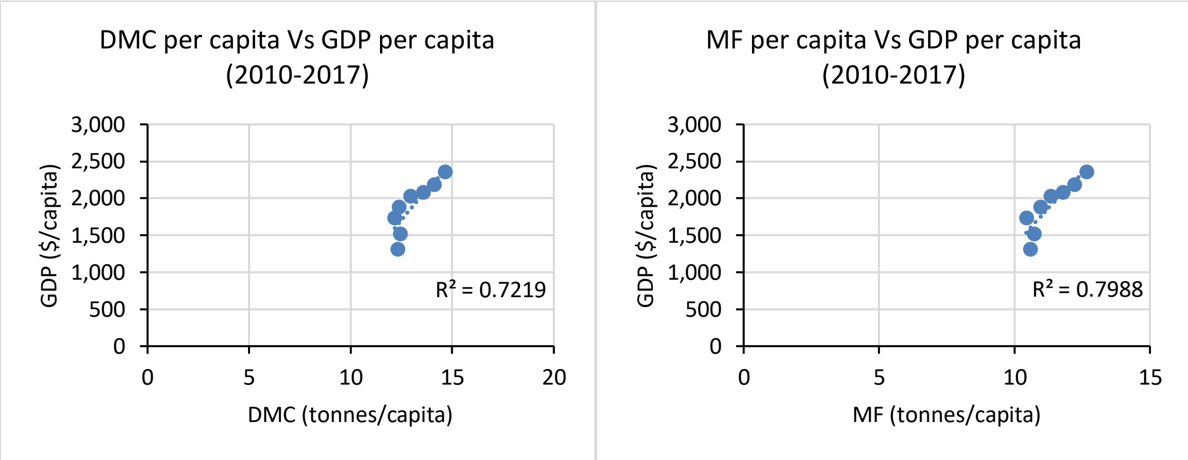

Figure 3-182 The relationship between material use (DMC per capita), and material footprint (MF per capita) versus the GDP per capita, Viet Nam (2010, 2017)

In **Figure 3-182**, Viet Nam's DMC per capita (tonnes/capita) and material footprint per capita (tonnes/capita) is plotted against GDP per capita for 2010 and 2017. It can be seen that both DMC per capita and material footprint per capita has a positive and very strong relationship with GDP per capita. However, for Viet Nam, the correlation between material footprint and GDP is slightly stronger as compared to DMC and GDP as the value of correlation coefficient "*r*" between DMC and GDP, and material footprint and GDP was 0.8478 and 0.8951, respectively, from 2010 to 2017.

3.6.1.9 Physical trade balance

Agricultural sector

Viet Nam is an emerging economy that has experienced rapid growth during the last few decades, especially in animal-based protein production[279]. This caused Viet Nam to become heavily dependent upon feed ingredients such as corn from other countries[280]. Viet Nam changed from a marginal net exporter to a major net importer in 2013 (**Figure 3-183**). The major crops were rice, sugarcane, cassava, corn, and nuts. The trade surplus climbed dramatically by 223% in 2013 resulting from increases in foreign investment in production

[279] Arita, S.S., and Dyck, J. (2014). Vietnam's Agri-Food Sector and the Trans-Pacific Partnership, , U.S. Department of Agriculture. https://www.ers.usda.gov/webdocs/publications/43899/49392_eib130.pdf?v=0.
[280] USDA Foreign Agricultural Service (2021). Vietnam: A Feed Importing Powerhouse, International Agricultural Trade Report, U.S. Department of Agriculture. https://www.fas.usda.gov/data/vietnam-feed-importing-powerhouse.

facilities as agricultural imports entered with very low tariffs[281]; however, the surplus remained stable from 2014 to 2017. **Figure 3-184** shows PTB per capita stayed around 0.03 tonnes per capita from 2013 to 2015 and increased by 0.01 tonnes per capita in 2016 and 2017.

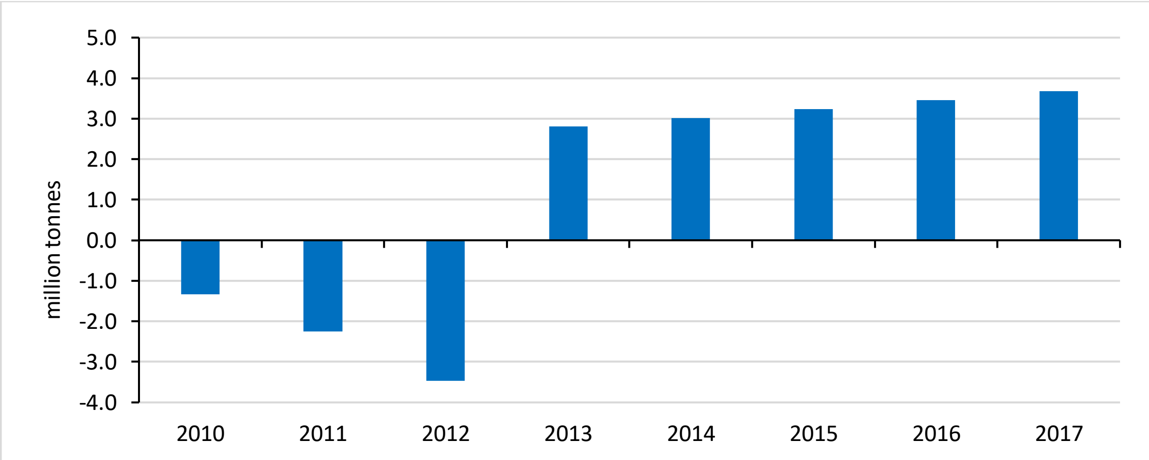

Figure 3-183 Physical trade balance (PTB) by agricultural sector in Viet Nam, 2010 to 2017

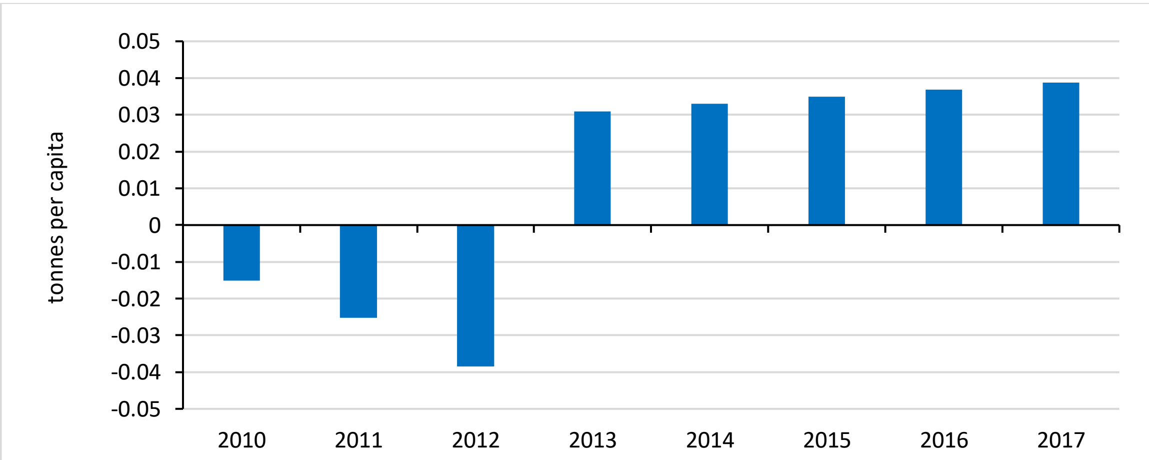

Figure 3-184 Physical trade balance (PTB) per capita by agricultural sector in Viet Nam, 2010 to 2017

[281] Tran, Q. (2013). *Vietnam Grain And Feed Annual 2013, GAIN Report Number: VM3016*. USDA's Foreign Agricultural Service, Global Agriculture Information Network. http://www.thefarmsite.com/reports/contents/vngap13.pdff

Food sector

Under Viet Nam's export-led growth strategy, it led Viet Nam changed in net importer status in 2013 (**Figure 3-185**). The exported food dropped by 48% which might cause by the protection of Vietnamese agriculture under trade liberalization[282]. The PTB per capita remained around 0.02 tonnes per capita since 2013 (**Figure 3-186**).

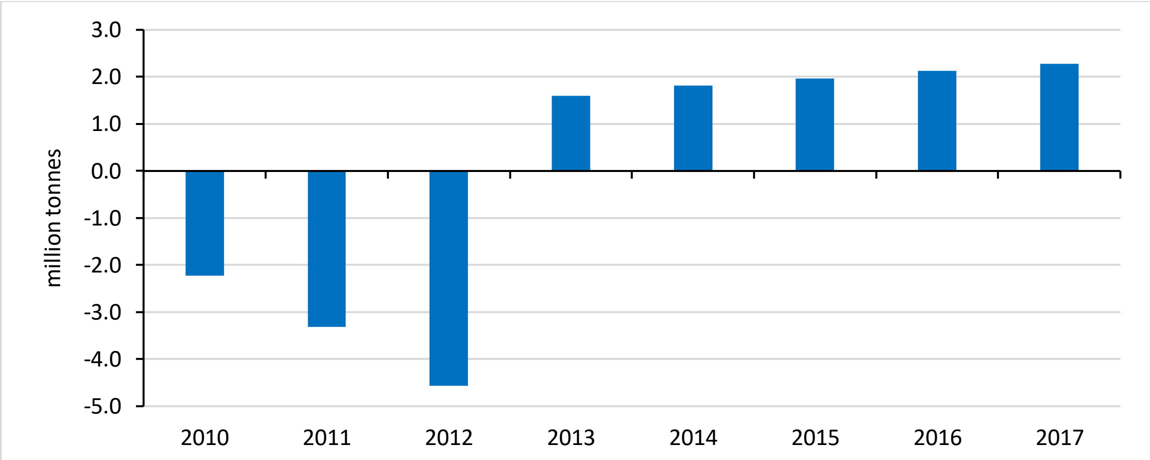

Figure 3-185 Physical trade balance by food sector in Viet Nam, 2010 to 2017

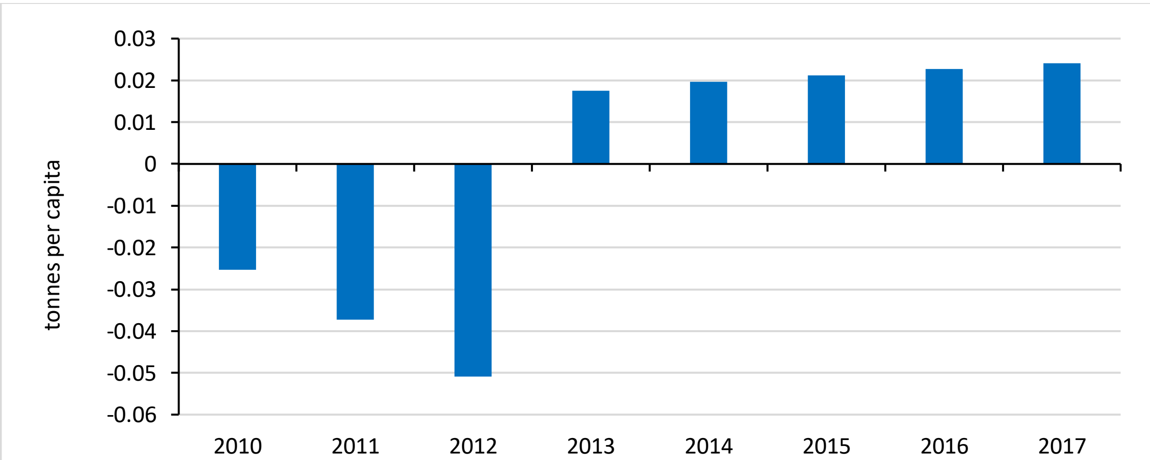

Figure 3-186 Physical trade balance per capita by food sector in Viet Nam, 2010 to 2017

[282] Dinh, B.H., Phuc, H.N., Bui, T., & Nguyen, H. (2020). Declining Protection for Vietnamese Agriculture under Trade Liberalization: Evidence from an Input–Output Analysis. *Economiess, 8* (2), 43. https://doi.org/10.3390/economies8020043

Construction sector

Viet Nam experienced a rapid increase in its deficit in the construction sector in 2011 by 104% and then the deficit stayed relatively constant after 2015 (**Figure 3-187**). It also shifts construction trade from net exports to net imports in 2011. The exports jumped sharply by 70% in 2011. In contrast, in the same year, the imports fell dramatically by 173%. The PTB per capita was -0.18 tonnes per capita in 2017 and the growth rate was quite gradually since 2012 (**Figure 3-188**).

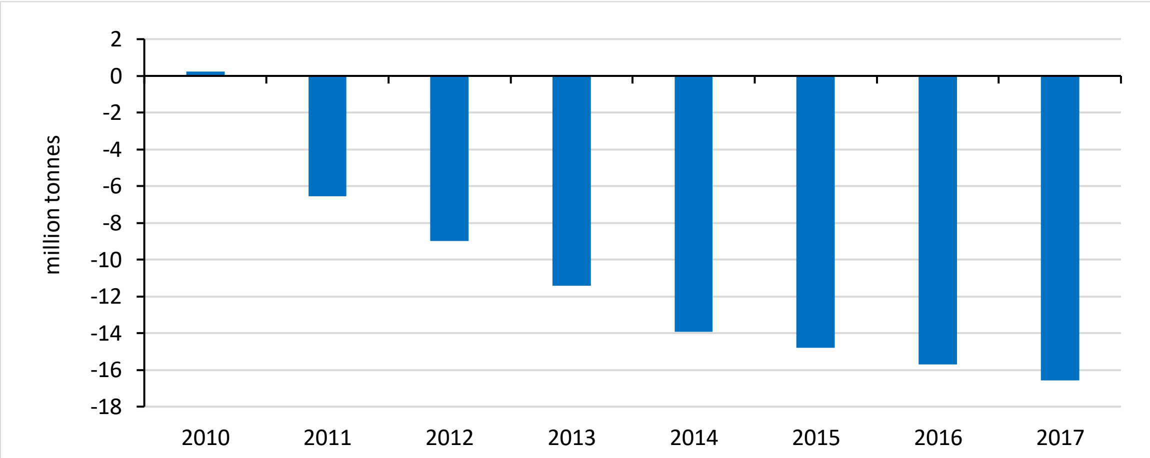

Figure 3-187 Physical trade balance by construction sector in Viet Nam, 2010 to 2017

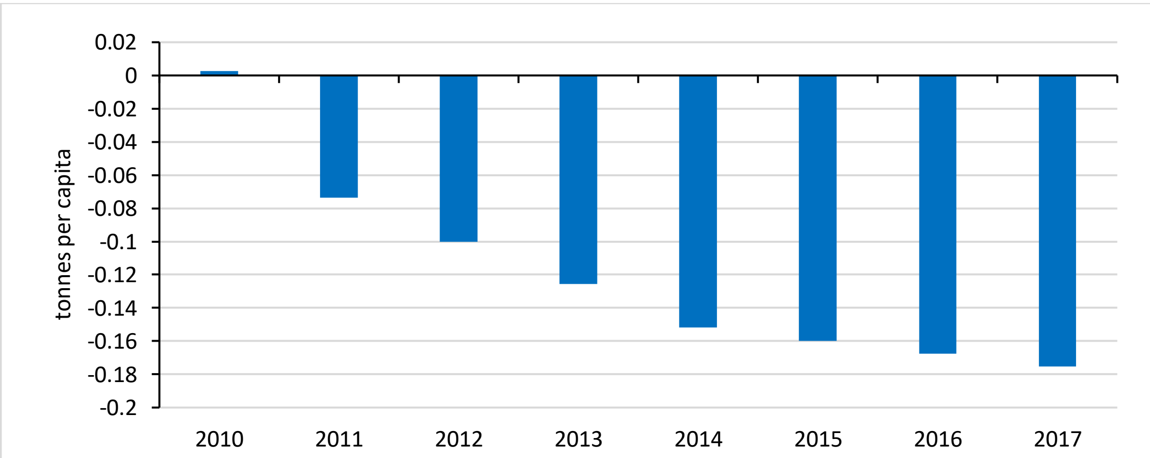

Figure 3-188 Physical trade balance per capita by construction sector in Viet Nam, 2010 to 2017

3.6.2 Consolidated discussion

In Viet Nam, renewable energy, material use, and GHG emissions are increasingly driven by the increase in population, urbanization, industrial development, and economic growth, which influenced sustainable consumption and production patterns. Moreover, increased activities in the manufacturing industry and infrastructure development are causing an increase in water use in the construction and food sectors. On the other hand, land use in the agricultural sector is increased which may be due to the economy's dependence on agricultural commodities. The country is implementing its Doi Moi Economic Reforms for sustainable economic development, National population policy to control the increasing population, Resolution No 23/NQ/TW of National Industrial Policy for sustainable industrial development, and Viet Nam's National Environmental protection Law to take measures for protecting the environment. A summary of SCP indicators and issues considering the DPSIR framework for Pakistan is presented in **Table 3-8**.

Table 3-8 A summary of SCP indicators and issues considering the DPSIR framework for Thailand.

Drivers/Pressures	State/ impact	Responses
- Increasing population (88 million in 2010 to around 94 million in 2017) - Increased economic activity ($US 1,318 per capita in 2010 to $US 2,366 per capita in 2017 and total GDP from $US 116 billion in 2010 to $US 224 billion in 2017) - The urbanization population has increased	- Domestic material consumption increased from 0.7 billion tonnes in 2010 to around 0.9 billion in 2017 - The additional potential of solar PV, increasing from 16.6 GW to almost 19-20 GW, and onshore wind, doubling from 0.6 GW to 18-196 GW - The food sector is the major contributor to land use. • Land use of the food sector increased to 7.17 million hectares in 2018 which was 3.52 million hectares in 1990.	- Doi Moi Economic Reforms for sustainable economic development - National population policy to control the increasing population - Resolution No 23/NQ/TW of National Industrial Policy for sustainable industrial development - Viet Nam's National Environmental protection Law to take measures for

Drivers/Pressures	State/ impact	Responses
from around 30% in 2010 to 37% in 2020 - Rapid industrial development is being carried out - Increasing domestic demand owing to an increase in GNI	- The construction sector is one of the major contributors to water use. • Water use in the construction sector was 0.35 billion cubic meters in 2018 - GHG emissions increased from around 320 million tonne CO_2eq. in 2010 to around 380 million tonne CO_2eq. in 2015.	protecting the environment

3.7 Missing data information

The water and land use data for textile, plastic, and SMEs sectors were missing.

The unit price of the trade is related to countries' monetary income /expenditure for each unit mass of exports /imports. To analyze the indicator in sector wise, unit price requires total imports, total exports, the total price of imports, and the total price of exports in thirteen sub-categories. However, the data on the total price of imports and exports was not available.

The sectoral data for the quantity of waste generated from the agriculture, energy, household, transportation, and industrial sector translating to agricultural waste, municipal waste, electronic waste, hazardous waste, industrial waste, and sewage data were missing. It is imperative to state that information on waste management techniques (waste recycled, waste landfilled, waste incinerated, etc.) and the quantities of waste managed by the various sectors were also missing.

This inclusive green recovery is focusing on specific sectors (such as transport, buildings, energy, and/or research & development); therefore, it was also excluded from the country profile report.

The debt and inflation data related to sectoral contribution was missing for both indicators (i.e., the general government gross debt and inflation). Therefore, these indicators were also excluded from the report.

The ‘foreign direct investment’ can be used as an indicator to assess the investment in the Asia Pacific region. Unfortunately, the sector based classified data was missing for the considered indicator. Therefore, this indicator is not considered in the country profile reports.

For energy use, three different indicators were selected including the total installed renewable capacity, installed renewable capacity per capita, and sectoral share in total final energy consumption. The data related to the required sectors (i.e., tourism, food, construction, textile, mobility, plastics, and SMEs) were not available; however, the available dataset contained following sectors, industry, transport, residential, non-energy use, commercial and public services, agriculture/forestry and non-specified.

The energy intensity of the economic data related to the required sectors (tourism, food, construction, textile, mobility, plastic sme) was not available; however, the country-wise trends have been discussed in the report.

Chapter 4 Conclusion

In this study, a regional assessment was carried out providing a comprehensive analysis of the interlinkages between SCP indicators and regional issues in the Asian region. The detailed observation of SCP patterns and regional issues interlinkage was carried out through the DPSIR framework, i.e., drivers, pressures, state, impacts, and responses as summarized in **Figure 4-1**. The analysis of cause and effect relationship revealed that economic growth and population are significant drivers putting pressure on natural resources and the environment. These were observed and reflected through the chosen SCP indicators. The level of SCP adoption in the region was explored considering the available data to reflect the existing policies and practices of different countries and sectors. Furthermore, examples of both the consistent and effective SCP policies and best practices being adopted by the businesses are presented to inspire the countries and businesses towards improved performance.

Overall, it was found that renewable energy, material use, and GHG emissions are increasing driven by the increase in population, urbanization, industrial development, and economic growth. The consumption and production patterns have increased significantly in recent decades, causing resource depletion and pollution, far beyond the ecosystem's regenerative and assimilative potential. Resource depletion and pollution are posing serious threats to the major sectors, especially industry and agriculture which are the largest contributors to the economy of the country.

For instance, in Pakistan, the reduction of land use in the agricultural sector was observed due to natural disasters such as droughts. In India, land use in agriculture has been nearly steady from 1990 to 2018. The change in agricultural productivity, on the other hand, has been erratic, ranging from 5.8 percent in 2005-06 to 0.4 percent in 2009-10 and -0.2 percent in 2014-15. Similarly, rapid industrialization in India and China has resulted in high GDP. However, it has led to a large increase in GHG emissions, primarily due to increased energy demand. The same can be said for Vietnam, which saw its total GDP nearly double from 2010 to 2017 as a result of rapid industrialization. Due to the rise of the manufacturing industry and accompanying infrastructure, this has also resulted in an increase in water use in the building sector in Vietnam. On the other hand, the reduced availability of water in Thailand and Indonesia is causing a reduction in water use in the agricultural sector.

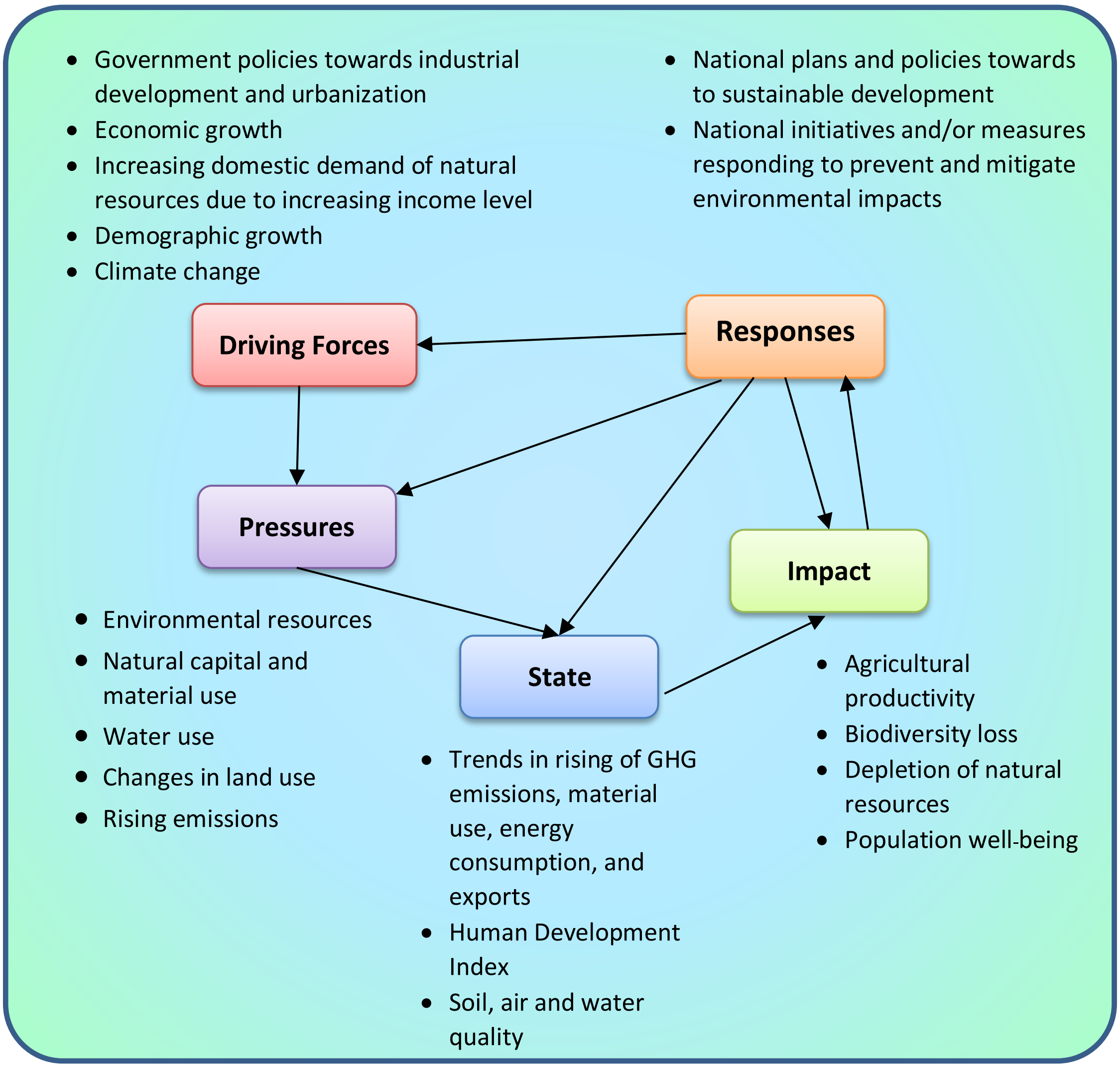

Figure 4-1 Summary of interlinkages between SCP pattern of selected significant sectors and regional issues represented by six national economies in the Asian region

Currently, the governments are putting their action plans for population management, a more favorable trade balance, and environmental protection measures into effect. The countries have started various initiatives to shift their development from conventional to sustainable development. For instance, Indonesia's Long-Term Strategy for Low Carbon and Climate Resilience 2050 (LTS-LCCR 2050), Viet Nam's National Environmental Law, Thailand's Environment Quality Management Plan 2017-2036, India's National Action Plan for Climate

Change (NAPCC), China's Building of the Ecological Civilization, and Pakistan's National Energy Efficiency and Conservation (NEEC) Policy 2022 are such examples of countries' measures towards a sustainable future.

Understanding the linkage between SCP patterns and countries' problems has led to explore potentials and opportunities for regional sustainable improvement. This effort is expected to contribute towards the improvement of SCP performance in the region and solve the regional issues through capacity building, situation awareness, and following the best practices. Investigation of sectoral performance for intensive sectors would help to make the interventions in concerned areas to achieve the notable improvement.

The DPSIR approach was followed in this study; nevertheless, the classification of indicators among the framework's categories (i.e. driver, pressure, state, impact, and response) is ambiguous. As a result, the interested stakeholders' awareness of the cause--effect chain can be affected. Although the trade balance has been included in the research, it is missing external elements that may have an impact on environmental performance. Another issue is the non-availability of data for several of the metrics that has been mentioned in the report as well. The databases, particularly the national databases, need to be made easier to use and more synchronized.

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Potentials and opportunities for improvement by countries and businesses