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REGIONAL INDICATORS AND DATABASE ON RESOURCE EFFICIENCY IN ASIA

Measuring progress of sustainable consumption and production, green economy, and resource efficiency

UNITED NATIONS ENVIRONMENT PROGRAMME

Regional indicators and database on resource efficiency 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 indicator and database on resource efficiency in Asia. Authors: S. H. Gheewala, H. U. Ghani, P. Nilsalab, P. Pongpat, A. Mahmood, K. Fangmongkol, A. Farooq, H. Akbar, and A. A. Gazal, Output under SWITCH-Asia Regional Policy Advocacy Component Supported by European Union.

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Abstract

The Asia Pacific region is home to 60% of the world's population, and it is predicted that the region's worldwide yearly gross domestic product (GDP) share would climb to 50% by 2030. The region consumes 60% more natural resources per unit of GDP and emits 20% more CO_2 per unit of value added than the global average. As a result, resource efficiency has arisen as a key concern for the region. This report is aimed at presenting the indicators and inventory databases on resource efficiency in the region. Overall, it was revealed that the material use, energy use, and emissions, especially greenhouse gas emissions, and waste generation have been increasing over time under the driving force of promising economic growth. Considering the trade balance indicators, the region has been a global exporter. The intensity of resource use, agriculture productivity, and access to electricity, water, and sanitation have been improving with time indicating a progress towards decoupling of environmental impacts from economic growth. Many nations in the region with lower development indices have spent less on rescue and recovery measures, thereby jeopardizing poverty rates, health outcomes, and the path of sustainable development. Despite the improvements, the pressure in terms of resource use and environmental damages is still very large requiring an escalation of efforts for further improving the resource efficiency. The availability of a diverse range of relevant indicators and comprehensive databases would help the decision makers (both policy and businesses) to formulate a suitable response to complex situations in the region. Furthermore, it is suggested to develop the regional indicators for assessing the efficacy of public infrastructure use, circular economy performance, plastic waste generation, air and water quality, fishing, gender equality, and blue economy.

Highlights

- The Asia Pacific region's resource efficiency has emerged as a major challenge.
- Population, economic growth, and urbanization are the main driving forces for consumption and production patterns.
- Resource use, pollutants, and emissions are increasing over time.
- The region is the most significant contributor to global exports in the world.
- Despite positive fiscal steps, green recovery is still not a widespread aspiration.
- Resource intensity is improving with time showing the progress towards decoupling.
- Despite some improvements, there is a still a rather large pressure from resource use and environmental damages.

Acknowledgements

This report has been prepared as part of the project entitled "strengthening resource efficiency and sustainable consumption & 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 (JGSEE), King Mongkut's University of Technology Thonburi. The goal of this report is to select and finalize the relevant regional indicators, identify current sustainable consumption and production hotspots, increase access to accurate data, and assist nations in assessing their present consumption patterns. The resource efficiency indicators and databases for 18 major nations of the Asian region are presented in this report. This will assist in making informed decisions to improve resource efficiency to meet the national targets of sustainable development goals.

The authors would like to acknowledge the guidance and support of the SWITCH-Asia Regional Policy Advocacy Component (RPAC), implemented by the United Nations Environment Programme. The authors are also thankful to the European Union for the financial support through the SWITCH-Asia Project.

Abbreviations

ASEAN	Association of Southeast Asian Nations
CSIRO	Commonwealth Scientific and Industrial Research Organization
DMC	Domestic Material Consumption
EDGAR	Emissions Database for Global Atmospheric Research
EV	Electric Vehicle
FAME	Fatty Acid Methyl Esters
FAO	Food and Agriculture Organization of the United Nations
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GNI	Gross National Income
GWP	Global Warming Potential
HDI	Human Development Index
HPI	Human Poverty Index
IEA	International Energy Agency
IMF	International Monetary Fund
LULC	Land Use and Land Cover
MF	Material Footprint
MPI	Multidimensional Poverty Index
PTB	Physical Trade Balance
PV	Photovoltaic
RACER	Relevant, Acceptable, Credible, Easy and Robust
SCP HAT	Sustainable Consumption and Production Hotspot Analysis Tool
SCP	Sustainable Consumption and Production
SDG	Sustainable Development Goals
UN	United Nations
UNCTAD	United Nations Conference on Trade and Development
UNDP	United Nations Development Programme

UNEP	United Nations Environment Programme
UPE	Unit Prices for Exports
UPI	Unit Prices for Imports
US / USD	United States Dollar

Chapter 1 Overview

1.1 Introduction

According to estimates, the population of the Earth will reach 9.7 billion by the year 2050 (United Nations, 2021). This will require almost three earth equivalent planets for natural resources to meet the demands of the current lifestyle (Doran, 2021). The rising population, rapid urbanization, and changing lifestyles have already put an enormous pressure on the carrying capacity of the Earth. For instance, in 2021 (WWF, 2021), the world exhausted its annual budget for natural resources on 29th July 2021. More than 55% of the population is now living in urban areas compared to only 30% in 1950, and it is consuming 75% of natural resources while occupying only 0.5% of the global surface area (Lioutov, 2020).

This extreme pressure on planet earth is generating the triple planetary crisis, i.e., climate, biodiversity loss, and pollution (Passarell et al., 2021). The target of limiting the temperature increase to 1.5°C higher than pre-industrial levels is going to be exceeded in just the next decade (IPCC, 2021). Biodiversity loss could threaten around 80% of sustainable development goal targets. The pollution and waste from the economic growth are resulting in millions of premature deaths. The root cause of this crisis is unsustainable consumption and production as evident from the findings of the International Resource Panel that unlimited natural resource extraction is driving limate change, damaging the nature, and increasing the pollution (UNEP, 2020).

Under the United Nations' sustainable development goals, the concept of sustainable consumption and production (SCP) focuses on decoupling economic growth from environmental degradation. The decoupling is only possible by improving the resource efficiency and advocating behavior change (UNEP, n.d.). The importance of sustainable consumption and production and natural resource management was thus recognized in the United Nations Conference on Sustainable Development, RIO+20 as one of the essential requirements for a sustainable future (EEA, 2012). SCP is a cross-cutting and multidisciplinary concept involving coherent and effective policies, trade dependency, businesses, resource efficiency, and behavior changes. The understanding of the current status and future implications of SCP is a fundamental requirement for developing evidence-based coherent and effective policies. The availability of data contextualizing the regional circumstances revealing the complex interlinkage of SCP and regional issues, is essential for the relevant stakeholders in productive decision making. This is particularly more important for a resource-intensive region such as the Asia Pacific, where attention is required to develop the regional databases.

In 2021, the Asia Pacific region was expected to achieve a GDP growth of 6.2% that was slowed down to only 2.2% in 2020 due to the COVID-19 global pandemic. The economic growth trends of the region are showing a promising performance and the region is rapidly transitioning from low to middle income (ADB, 2020). Nevertheless, this progress has been achieved at the expense of high environmental and social costs. The region is off-track on consuming a global fair share of sustainable use of natural resources. For example, the region is consuming 60% more natural resources per unit of GDP and emitting 20% more CO_2 per unit of value added than the world average (ESCA, 2020).

SCP focuses on achieving more with less, as well as detaching economic growth from environmental damage. Consumption and production are important to the global economy. However, current unsustainable production and consumption practices contribute to deforestation, excessive carbon emissions, food waste, water scarcity, and ecological degradation. The SCP targets will help to create synergies and aid in the achievement of other food, water, and energy goals, as well as contribute to the mitigation of climate change (United Nations, n.d.).

The regional indicators are introduced for measuring the performance of the region towards achieving the targets of the sustainable development goals. The development of regional indicators could help to obtain the region-specific quantitative values of different variables measuring the state or change in the system (Fiksel et al., 2013). The availability of regional data will assist in perceiving and analyzing the interlinkage between resource efficiency and regional issues. Furthermore, enabling the interpretation of the past trends and hotspot identification at the country level would support the prediction of future responses and the development of science-based national policy frameworks.

The performance of the region is still lacking in meeting the required targets of many sustainable development goals, such as responsible consumption and production (SDG 12). Across the regions, responsible consumption and production was among one of those indicators for which the subregions have manifested a varied performance (ESCA, 2020). The inability of the region to efficiently use natural resources, manage waste properly, cope with the effects of natural disasters, and adapt to the impacts of climate change are the key factors driving unsustainable consumption and production patterns. Hence, the region needs to put extra efforts into responsible consumption and production targets by applying the concept of resource efficiency and circular economy. Furthermore, to reflect or measure the progress of the region, the evaluation of state and progress of resource efficiency is required in the Asia Pacific region.

This report is aimed at updating and finalizing the regional indicators and inventory databases on resource efficiency in the Asia Pacific region. Accordingly, a conceptual framework was established for selecting the most relevant regional indicators for the Asia Pacific region. This was followed by the development of a comprehensive inventory database along with a concise discussion of past trends and hotspots identification. The focus is on identifying the priorities for policy makers for solving the regional problems and supporting the improvement of resource efficiency by accelerating sustainable consumption and production.

In this report, resource efficiency indicators and databases are presented for 18 selected major countries of the region. Wherever required, the sectoral data and a comparison of industrialized and developing nations of the region are also provided. A wide range of the most relevant indicators including resource use, emissions, economic performance, resource efficiency, and human development, etc., have been used. Considering the COVID-19 global pandemic, the green recovery indicator is also applied to show the effect of different policies, financial instruments, and pathways adopted by the countries of the region for an inclusive and green recovery from the current global crisis. The progress of different initiatives has also been evaluated aiming to understand their outcome on the performance of sustainable consumption and production and resource efficiency.

Accordingly, the database and information provided in this report will give insights and encouragement for improving the resource efficiency in the region via an easily accessible and credible database, highlighting the interlinkage of sustainable consumption and production and regional issues, and linking the scientific knowledge and policy interventions. It will raise the awareness of concerned stakeholders (i.e., decision makers, businesses, and the public, etc.) on the current situation of countries. The observation of policy outcomes and comprehensive analysis of trends will foster target setting and development of effective and coherent policies improving the resource efficiency performance for solving the regional problems.

Chapter 2 Conceptual framework

2.1 Why is resource efficiency important for the Asia Pacific region?

The Asia Pacific region is the home to more than 4 billion people representing 60% of the world population (UNFPA, n.d.). By 2030, the global annual GDP share of the region is expected to increase up to 50% while the annual per capita GDP growth of the region will be around 3% (APF Canada, 2016). The urban population of the region is also increasing at a rate of around 2% per annum (World Bank, 2020c). The increasing trends of disposable income, population, and urbanization are rapidly changing the behavior of consumption patterns towards a material affluent society.

In the recent past, the Asia Pacific region has achieved considerable progress in economic and social development. The middle class population of the region has been increasing exponentially compared to other regions. For instance, in the year 2030, the middle class population of the region is expected to reach 3.49 billion from only 1.38 billion in 2015 (Szmigiera, 2021a). The increasing population, urbanization, and economic prosperity are driving the consumption patterns. A graphical representation of change in population, annual GDP per capita growth, and urban population in the Asia Pacific region is shown in **Figure 1**.

The available resources on the planet will not be able to keep up with the increasing demands which will cause irreversible damage. It is perceived that the region will represent half of the global consumption by 2030 (UNEP, 2015a). However, the material use efficiency of the region is three times lower than the world average. Considering the progress of sustainable consumption and production (SCP) in the Asia Pacific, the region is far behind the SDG 12 targets to meet the deadline of 2030 (ESCAP, 2020).

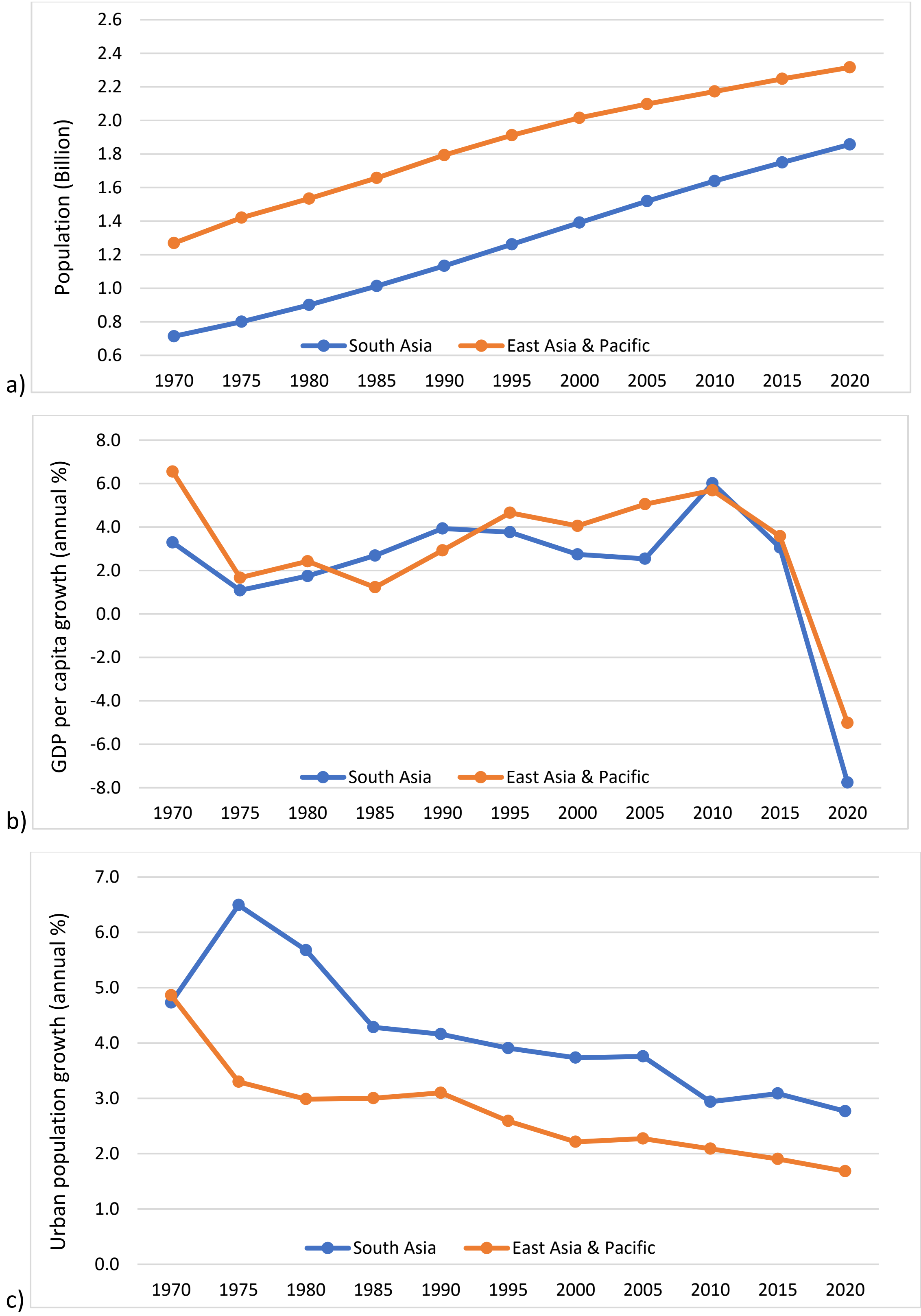

Figure 1 The graphical representation of (a) Population, (b) GDP per capita growth (annual %), and (c) urban population growth (annual %) of South Asia and East Asia and Pacific region for the years 1970 – 2020

We are living in a resource-constrained world and the current global consumption patterns are already exceeding the limits of available resources. SCP plays a vital role in diminishing the negative impacts of resource use by enabling the effective engagement of market actors, i.e., supply chain via production perspective and demand side via consumption perspective. The contemplation of both the production and consumption aspects at the same time helps to obtain an integrated overview of resource use from the economic activities. Thus, it is crucial for the Asia Pacific region, especially countries of the developing and emerging economies, to achieve a transition towards enhanced resource efficiency by decoupling the economic growth from environmental degradation. The change will not come spontaneously; rather, it requires a consistent and long-term solution. The critical need of changing resource use trends represents an opportunity, especially for the developing nations, to change the patterns by adopting coherent and effective policies, innovative design practices, and raising sustainability awareness.

2.2 Barriers and challenges for enhanced resource efficiency

The main challenges from the policy side (i.e., government) are the lack of coherence among sectoral policies, lack of holistic approach (i.e., covering all the sectors, products, and life cycle stages), and generic policies (i.e., policies without quantified targets and impacts). The developing nations of the region are not being able to create the enabling environment through legal binding and economic incentives (e.g., upfront on green energy, financial support for green technologies, and preferred procurement of green products, etc.).

The major challenges from the perspective of the producer are the lack of access to the capital market, lack of supporting infrastructure, and ineffective cooperation of stakeholders (i.e., government, technical experts, and financial institutions, etc.). Due to the growing scarcity of resources, the businesses of the region are emphasizing resource efficiency in the production stage and waste management to reduce the dependence on virgin materials; however, they are yet to fully explore the circular business models such as reuse, repair, recycle, and product as service, etc. A campaign for Right to Repair legislation was recently initiated, which would provide consumers access to tools to be able to repair their equipment rather than relying on professionals from the manufacturing companies. This would save users money and time while also conserving valuable resources. The application of advanced and innovative technologies is also facing challenges in terms of technical capacity and financial limitations (i.e., high investment, financial risk, access to finance, and profit structure, etc.).

Considering the consumer side (i.e., public), the challenge in the Asia Pacific region is behavior change by convincing the consumers that a more sustainable lifestyle leads to enhancing wellbeing. The need is to make sustainable products more appealing, accessible, and affordable, for the consumers. Traditionally, the people of Asia have been sustainable consumers sharing resources and responsibilities making the maximum out of available resources. However, with advancements in purchasing power and western influence, things have changed. While millennials are more aware of the environmental impacts of their consumption patterns, studies have found that despite their willingness to purchase green products, Asians are not consuming green. This is mainly because of limited access to green products, lack of transparency in specifying the green products, inadequate waste management facilities, and limited take-back schemes (SWITCH-Asia Network Facility, 2013; UNEP, 2021).

The non-availability of data for regional indicators informing the condition of resource efficiency is a big issue in the Asia Pacific region. Easy access to authentic information could serve as a starting point to address the challenges pointed above by helping the development of more coherent and effective policies, applying the circularity principles, raising consumer awareness, and diverting the efforts towards the most critical resources, etc.

2.3 Conceptual framework for regional indicators

The increasing interest in the production and consumption patterns of resources have led to the development of multiple resource efficiency indicators. Henceforth, a conceptual framework is developed for identifying the most relevant as well as robust and easily understandable regional resource efficiency indicators for Asia Pacific. Prior to the selection of indicators, resource efficiency and related driving factors are reviewed and considered based on flows and impacts related to resource use. To begin with, it is important to understand the material flow under the influence of economic activities. The material flow of consumption and production, i.e., between the industrial system and the environment is illustrated in **Figure 2**. The inventoried flow of material exchange with the environment includes the direct exchange of natural resources and emissions. Natural resources are required by the industrial production systems to manufacture the products. These products are then used for the benefit of human beings. The life cycle of resources (extraction, transportation, production, consumption, and end of life cycle management) results in emissions (i.e., gaseous, liquid, and solid) that cause adverse environmental impacts. Therefore, indicators for resource efficiency should address all the aspects over the entire life cycle of resources.

The next step is determining the forces that will drive the businesses towards sustainability in the coming future. It has been anticipated that environmental damages being caused by the production activities around the world will start influencing these activities over the next two decades. Therefore, it is not only important for businesses to understand the need of incorporating resource efficiency in their businesses but also to select the relevant resource use indicators that will be influenced the most by these forces. Sustainability “megaforces” have been identified in different studies that will influence the production activities (please refer to **Figure 3**) (KPMG, 2012; Shuai et al., 2021). These forces were considered for selecting the regional indicators in this report. Additionally, a nexus approach with respect to the economic activity, that is widely employed by the World Economic Forum, is also taken into consideration for developing the methodological framework of regional indicators. This nexus approach consists of footprint nexus (i.e., increasing environmental footprints from human activities), erosion nexus (i.e., threat to the natural system from environmental footprints), and opportunity nexus (i.e., opportunity to address sustainability challenges through innovation). The footprint and erosion nexus indicate the need for resource efficiency while innovation nexus represents the solution for the businesses.

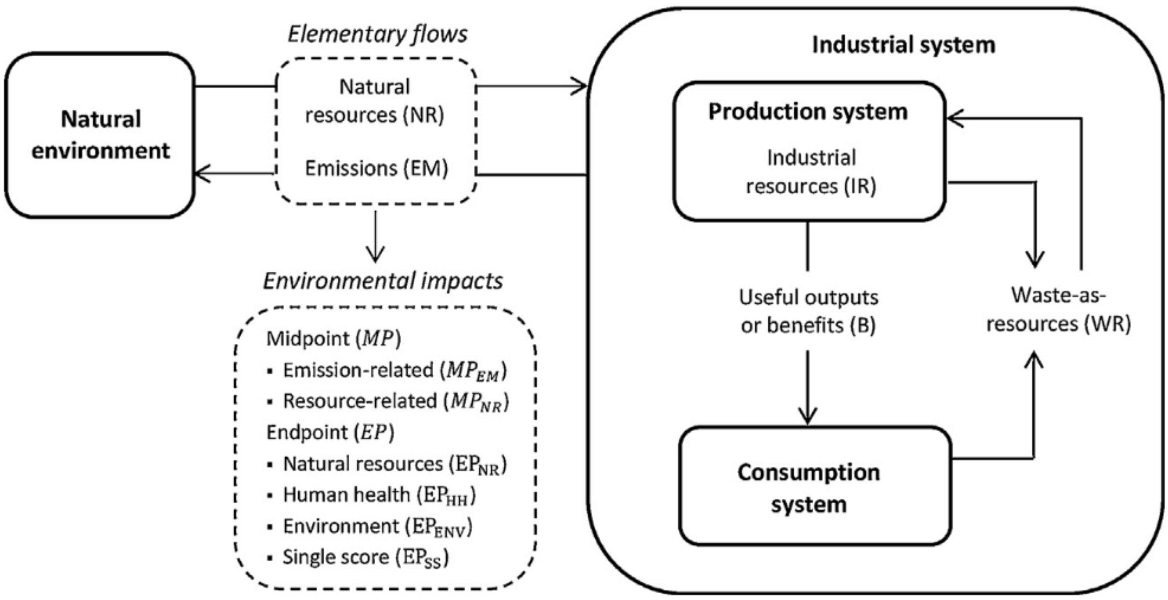

Figure 2 Flow and impacts related to resource use (Huysman et al., 2015)

Figure 3 Ten global sustainability megaforces (KPMG, 2012)

The available regional resource efficiency indicators are then selected by testing them based on RACER criteria (i.e., Relevant, Acceptable, Credible, Easy and Robust) as illustrated in

Figure 4. The RACER criteria were developed under the European Commission's Impact Assessment Guidelines; they help to identify the usefulness of indicators for policy linkage (Srebotnjak et al., 2009). The indicators are scrutinized considering their relevance (i.e., appropriate to achieve objectives), acceptability (i.e., adopted by the stakeholders), credibility (i.e., easily accessible and unambiguous), ease of use (i.e., feasible to monitor), and robustness (i.e., counter manipulative). Based on these criteria, the selected indicators should have the ability to support the policy targets and gaps, have stakeholder acceptance, be reliable, have data availability, and be supported by scientifically sound theory.

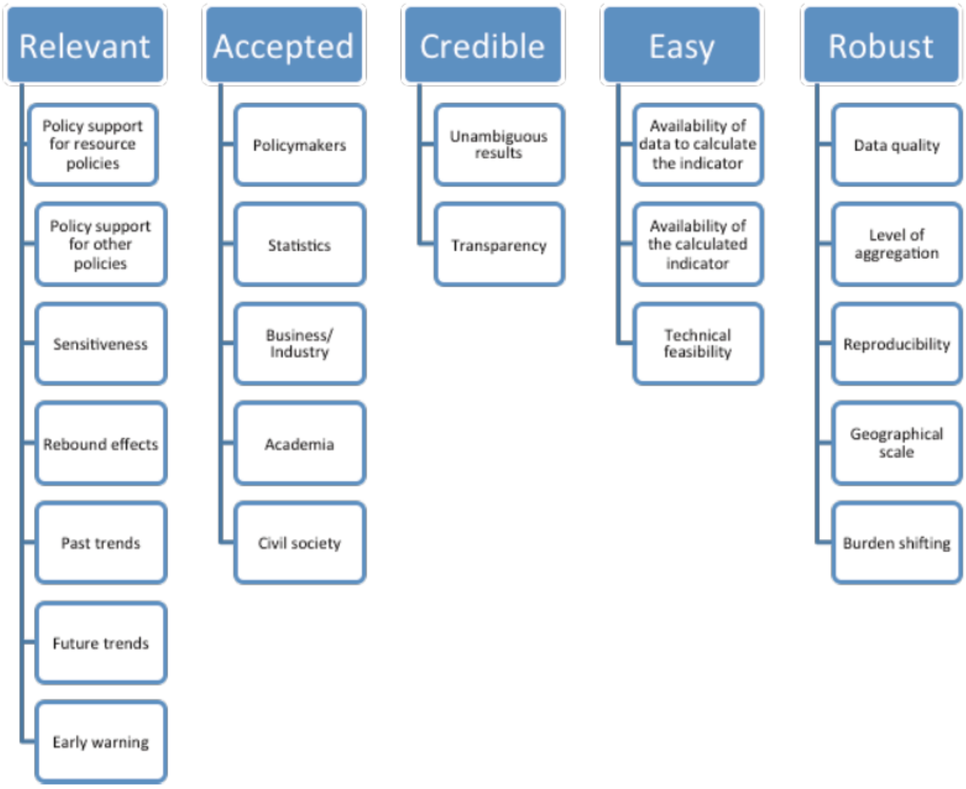

Figure 4 RACER criteria (Science Communication Unit, University of the West of England, Bristol, 2012)

This selection was made aiming to assist the policy makers and scientific community in solving the global (i.e., triple climate planetary crisis) and evolving regional issues. A wide range of indicators are selected covering all the aspects of resource efficiency: resource use (considering by means of natural resource use, emissions, impacts, and waste), resource efficiency (focusing on material and energy intensities of the economy), resource use in major sectors (manufacturing and construction are two key sectors related to material use, and emissions from energy sector are main focused), consumption-based indicators (in terms of footprints), trade dependency, and human development (GDP, debt, inflation, and access to energy, water, and sanitation), and inclusive green recovery. For an easy understanding of the reader, this grouping was made by keeping the consistency with the approach followed by the United Nations Environment Programme (UNEP) 2015's report. The list of selected regional resource indicators applied for different categories is shown in **Table 1**. A conceptual background of each indicator, provided in 2.3.1 to 2.3.10, is described by means of how it is linked to and represented for each category. As material use, renewable energy use, and water use are categorized into natural resources and resource use in major sectors, and related to consumption-based indicators in terms of footprint, thus a conceptual background of these indicators is elaborated in relation to those three aspects.

Table 1 The list of selected regional resource indicators applied for different categories

Category	Indicators
Natural resource	Material use, Renewable energy use, Water use, Land use, Agricultural productivity, Greenhouse gas emissions, Waste management
Resource efficiency	Material intensity of the economy, Energy intensity of the economy
Resource use in major sectors	Material use for manufacturing, Material use for construction, Emissions of the energy sector
Consumption-based indicators	Material Footprint, Water footprint
Trade dependency	Physical trade balance, Unit price of trade
Resources and human development	Economic Growth (GDP), Investment and consumption, Debt and Inflation, Access to energy, Water, Sanitation
Inclusive green recovery	COVID spending, Natural capital, Green spending, Green energy investments, Green transport, Green research and development

The overall conceptual framework is also illustrated in **Figure 5**. The framework is developed for the flow and impacts of resource use under the influence of sustainability forces. The green circle represents a boundary of environment that interacts with the grey (impacts) and yellow boxes (socio-economic influencers). The industrial system is mainly considered as a part of the socio-economic driver. The light blue circle and pink box are decision tools and concepts that will lead to achieve sustainable uses of natural resources and to less emission of pollutants.

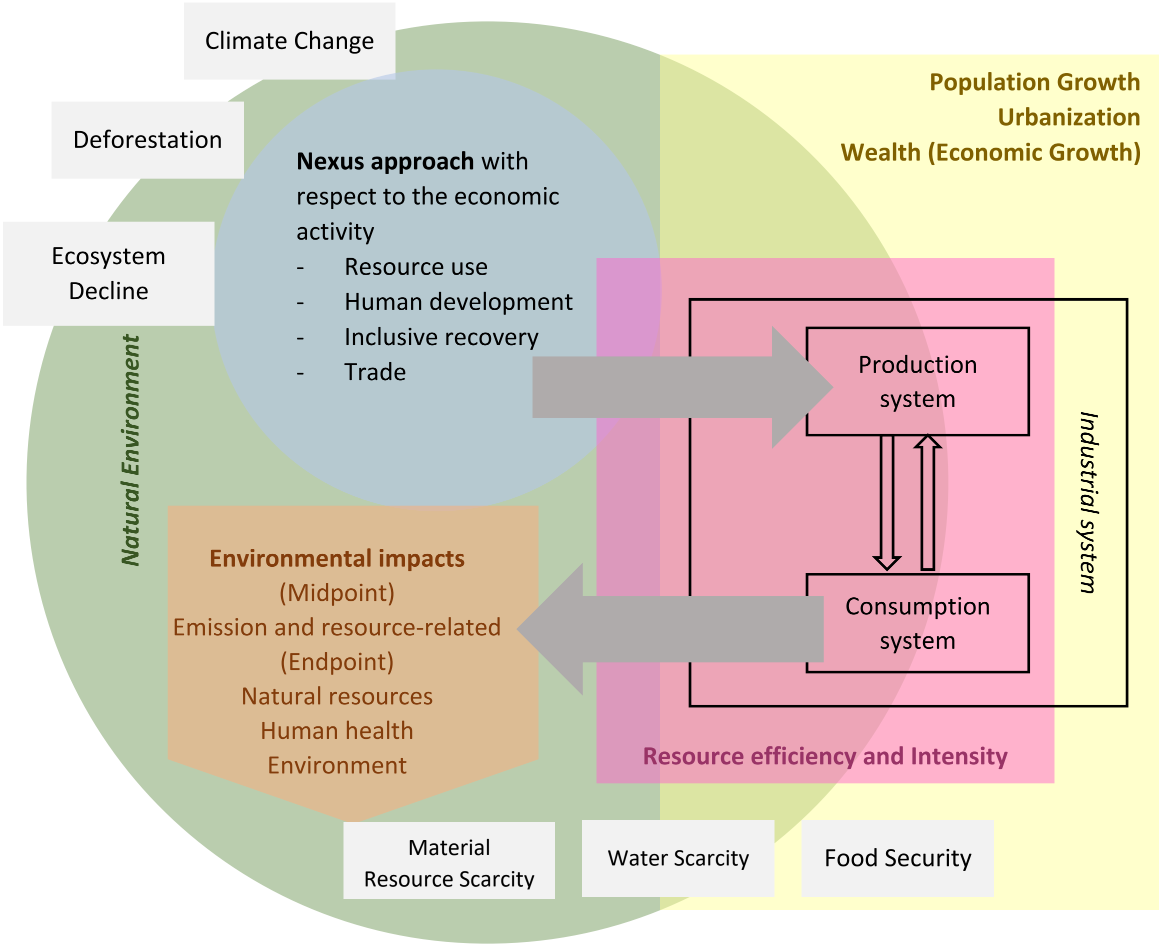

Figure 5 The overall conceptual framework of regional resource efficiency in the Asia Pacific region

2.3.1 Material use

Use of natural resources (fossil fuels, biomass, metal ores, and non-metal minerals) for production and consumption is essential to economic development. However, it can also contribute to the depletion of natural capital if not handled properly. Therefore, out of the 17 United Nations Sustainable Development Goals (SDGs), SDG 12 titled "responsible consumption and production is directly dedicated to ensuring sustainable consumption and production. The main idea of this goal is to encourage sustainable consumption and production by reducing natural resource exploitation, reducing the use of harmful materials, and relying on production practices that produce less pollution and generate less waste.

Increasing efficiency in consumption and production is also related to the target of SDG 8.4 (improving resource efficiency in consumption and production) and it encompasses the majority of material-related metrics. Besides, the targets of SDG 12.2 and SDG 8.4 are measured by the same indicators. Material footprint, material footprint per capita, and material footprint per GDP are mentioned both as indicator SDG 8.4.1 and indicator 12.2.1. Domestic material consumption, domestic material consumption per capita, and domestic material consumption per GDP are the same for both the indicator SDG 8.4.2 and indicator 12.2.2 (UNSTAT, n.d.).

To accomplish the sustainable development goals based on sustainable consumption and production, as well as efficient management of natural resources and ecosystems, the Asia Pacific region has begun a new route of economic development and has become the largest user of natural resources as well as the biggest producer in the world (Institute for Global Environmental Strategies, 2010).

In the United Nations Environment Programme (UNEP) 2015's report on "Indicators for a resource-efficient and green Asia and the Pacific", material use and waste was considered as a collective regional indicator. In that report, the domestic material consumption (DMC) indicator was used for material use as total DMC (tonnes) and DMC per capita (tonnes/capita); the material intensity was used as an indicator to measure material efficiency in terms of DMC per GDP (tonnes/US$), material footprint indicator was used as an attribute of material use to final consumption in a country in tonnes and tonnes/capita, and the material footprint per GDP was used as an indicator to measure adjusted material efficiency in terms of tonnes per US$. However, no indicators were mentioned to measure the sectoral material use. It was mentioned in the UNEP report 2015 that a lot of effort is required to develop indicators for sectoral material flows and waste. It was mentioned as:

"*Sectoral accounts of natural resource use attribute resources to those sectors that are using resources and hence attribute responsibility and allow for causation. For material flows and waste there are still unresolved conceptual issues and establishing indicators requires a lot of effort, if they are based on a national physical input-output table showing interdependencies among sectors in physical flows*".

In the present report, both material use and waste are analyzed separately, and all the indicators regarding material use, material efficiency, and material use of consumption (material footprint) will be used in the same way as in the UNEP report 2015. On the other hand, the data and information regarding sectoral material consumption are still not available. Therefore, the present report will not incorporate sectoral material consumption. However, the data will be updated in the indicators mentioned before. The UNEP report 2015, incorporated the data for DMC and material footprint from 1970-2010 and 1990-2010, respectively. In the new report, the data is used from 2010 to 2017 for both DMC, and material footprint. The data for gross domestic product (GDP) is available and will also be used from 2010 to 2017. The major data source for DMC and material footprint is the UN Environment Programme, while the data for GDP is extracted from the World Bank (2020a).

2.3.2 Renewable energy use

Asia is one of the diverse and dynamic regions of the world comprising some of the world's largest energy consumers and small island nations. Many of them are among the societies most vulnerable to the impact of climate change. Furthermore, the region is also afflicted by energy poverty and inequity. As energy is required to meet basic human requirements such as warmth and cleanliness, therefore, energy poverty is a social injustice that deprives people of their basic needs. Approximately 1.3 billion people live in darkness worldwide, with 620 million only residing in the Asia Pacific region. 'Energy poverty' or a lack of access to green, sustainable, and up-to-date energy services, affects a large number of persons living in rural areas in developing countries without power (Fitzgerald, 2021). People living in developing countries experiencing energy poverty are more likely to be harmed by fossil fuel emissions or spend too much time obtaining fuel to meet necessities.

Regional energy use, on the other hand, continues to rely significantly on fossil fuels. Furthermore, a large portion of the country still lacks electricity, forcing residents to rely on traditional energy sources (such as biomass) for cooking and heating. Since energy consumption is increasing as a result of rapid urbanization and industrialization, renewable and clean energy technologies have a huge potential. Governments, on the other hand, must make a strong commitment to making the transition to clean and green technologies practicable.

In this report, the indicator 'renewable energy share in total final consumption' expressed in terms of percentage share is considered, which is in accordance with the SDG Target 7.2.1. The data is used to analyze the situation of the Asia Pacific region towards renewable energy use (in terms of percentage of final consumption of energy which is derived from renewable resources). The data for this indicator is retrieved from the UN Environment Programme databank (UNEP, 2021).

In addition, energy intensity is a widely used index for assessing a country's energy efficiency. In general, the overall energy use-to-GDP ratio measures how efficiently the economy uses its energy in terms of monetary output. Low energy intensity is thus the desired aim, particularly from the standpoint of energy efficiency, since it shows the efficient deployment of energy resources to increase national prosperity. Using energy more effectively lowers costs and is a crucial step toward a low-carbon scenario for sustainable development. In this report, the energy intensity of an economy is measured in tonnes of oil equivalent per thousand 2015 USD. The data for this indicator is retrieved from the International Energy Agency (IEA) data bank.

2.3.3 Water use

Water use outnumbers all other natural resource usages in economic activity. Water is used significantly more than air[1] and all other materials[2] used in economic activities (UNEP, 2015b). Moreover, water is at the core of sustainable development and is essential for both socioeconomic development and human existence (UNSDSN, 2013).

The Asia Pacific region is by far the largest consumer of water, with a withdrawal rate of 2,384 billion cubic meters per year, which is greater than the rest of the world's consumption. (ESCAP, 2007). That is why it is important to assess the water withdrawal in activities of the economy.

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[1]The use of air, in volumetric terms, is dominated by the use of O_2 in combustion processes. The associated production of gaseous CO_2 is the main anthropogenic source of GHGs, however most CO_2 will revert to O_2 eventually naturally via photosynthesis, so air 'used' should not be thought of as depleting a non-renewable resource.

[2]Material resources are biomass, fossil fuels, metals and non-metallic minerals used in the economy

Water scarcity is spreading across Asia, especially in tropical countries that have traditionally been thought to have abundant water supplies. The few of the major drivers of increasing water scarcity are the desire for more and more diverse meals, as well as economic development and the rapid growth of cities and the water services they require. In general, the water scarcity can be defined as the ratio of water withdrawal to availability (FAO, n.d.). Mostly two indicators (viz., water availability and water withdrawal) are used to estimate the water use at the country level (UNEP, 2015b). There is no doubt that water availability is the key indicator for assessing water use, but water withdrawal is one of the best indicators that can be used for assessing water use at the country level (FAO, 1997). Economic activities are also directly related to water withdrawal (Kohli et al., 2010). Therefore, the sub-indicators, water intensity of the economy, water use in agriculture, water footprint of consumption, also based on water withdrawal, and access to water use, are used. Total water withdrawal and water use in agriculture data were obtained from FAO (FAO, 2022). Water use of economic data obtained from FAO and World Bank. The water footprint of consumption was obtained from Eora global (Eora global, 2021). Access to water use data was obtained from the World Bank (World Bank, 2021).

Due to agriculture expansion, water withdrawal for the agriculture sector is increasing especially in developing countries. An increase in water withdrawal by the agriculture sector may deprive the other users, e.g., domestic, and industry users. Moreover, the return flow deteriorates the water quality of groundwater resources. However, the domestic sector uses the finest quality of water. The rapid increase in population growth is one of the main reasons, for the decline of water withdrawal per capita. This is because water resources are not increasing at the same pace as the population. Moreover, the domestic and agriculture sectors in the Asia Pacific are withdrawing water almost equally (UNEP, 2015b).

2.3.4 Land area

In modern history, an ever-increasing pace has been noticed in the human development. As a result, remarkable shifts in land use have been observed (Winkler et al., 2021). Agriculture covers more than half of Asian land area and its expansion is Asia's most prevalent human land change activity. During 1700 to 1980, the total area of agricultural land in South and

Southeast Asia rose by 296 and 1275 %, respectively (Meyer, 1996). This expansion is driven by growth in population, GDP, and food requirements.

Many of the world's tropical rain forests and subtropical mountain forests are located in Asia (Zhao et al., 2006). Asia Pacific forests cover around 26% of the region's land area (FAO, 2015). South-East Asia's forests are vanishing faster than anywhere else on the planet; According to the Food and Agriculture Organization of the United Nations (FAO), the South-East Asian region lost 376 thousand km^2 of forest between 1990 and 2020, which is more than Germany's total land area (Russell, 2020). Deforestation on a large scale has happened in Asia, mostly as a result of agricultural expansion and timber extraction.

Land is an important resource and plays a central role, especially in the economies of developing nations (Azadi and Vanhaute, 2019). A major proportion of land is utilized in agricultural activities. Three indicators have been selected based on the recommendation of different UNEP (UNEP, 2014), and Asian Productivity Organization (O'Donnell and Peyrache, 2019) reports to qualify the role of land as a resource in economic development, viz., land use change, land productivity, and land use by major sector. Here, land use refers to the total area of land occupied by agriculture, urban, and forest area. The second indicator (land area by sectors) deals with the occupancies of land by major sectors (agriculture, urban, and forestry). The last indicator (land intensity) refers to the area of land utilization per GDP. The land use data from 1992 to 2015 was downloaded from the European Space Agency (ESA, n.d.) and processed in ArcGIS.

2.3.5 Agricultural productivity

Agricultural productivity is a major topic of discussion amongst policy makers as it measures the rate of output from the agricultural sector. Several declarations have highlighted the importance of agricultural production in emerging countries' economic and social agendas. These declarations place agricultural productivity increases at the forefront of efforts in many regions, including Africa, Asia, and Europe, to achieve agriculture-led growth and meet food and nutrition security targets. Information on agricultural productivity is related to the Sustainable Development Goal SDG 12 with indicators for food security such as cereal yield total, value of agricultural production, agriculture value-added per worker. Agriculture denotes the practices in which plants are cultivated and domestic animals raised to provide food and other products for sustenance of the world human population (UNEP, 2011). It has been the source of livelihood for humans since the days of the early men when agriculture was done on a subsistence basis (small scale). However, with the introduction of agricultural mechanization, improved farming practices, research, and technology, agriculture has since grown from its initial small scale to a big scale sector that is employed by many countries around the world to improve their economy. The agricultural productivity in this report is providing the information on several agricultural productivity indicators such as value of agricultural production, agriculture value added per worker, agriculture net production index number, and the land area agricultural area for every country which this report intends to examine. With the aim of monitoring the progress of agriculture, solving the inefficiencies of natural resource use, and how agriculture is improving the economy, these indicators are needed to give quantitative information to support policy makers in this regard. In this report, the agricultural productivity data from the year 2010 to 2017 has been sourced mainly from FAO (FAO, 2022).

2.3.6 Greenhouse gases

Over the years, anthropogenic greenhouse gas (GHG) emissions have been growing, and there is scientific agreement that this is a driver of climate change (IPCC, 2014). To mitigate and stabilize these emissions, a global policy to regulate activities called the Paris agreement was recently concluded by the world leaders. GHGs are also released from natural sources but the combustion of carbon-based fuels, agricultural practices, waste management, and industrial activities have increased GHG emissions substantially over the years. The GHG emissions from energy use indicator includes emissions from energy usage, which is by far the most significant source of human-caused greenhouse gas emissions worldwide. Transportation, electricity and heat, buildings, manufacturing and construction, and other fuel combustion are all part of the energy sector. Agriculture, such as livestock and crop cultivation, is the second largest source of emissions, followed by industrial activities such as production of chemicals, cement, and other materials; waste landfilling and wastewater; and land-use and land-use change (deforestation).

The GHG emissions assessment does not include short-cycle carbon emissions from agricultural burning or savannah fires, but it does include forest fires and peat emissions. The greenhouse gas total is reported in million metric tonnes of CO_2 equivalent, which includes total CO_2 from biomass burning (forest fires, post-burn decay, peat fires, and degradation of drained peatlands), all anthropogenic emissions of CH_4, N_2O, and F-gases (i.e., HFCs, PFCs, and SF_6). The GHG data from the year 2010 to 2015 were sourced from, Emissions Database for Global Atmospheric Research (EDGAR, 2019).

2.3.7 Waste management

The Asia-Pacific region has seen some of the fastest economic and population growth rates in the world in recent times, this growth comes with its demerits in the form of waste generation which is posing threats to the environment. These rising threats have been the impetus for stakeholders from private, public, and non-profit organizations to set-up schemes for improved waste management systems in the region.

Waste is defined as any substance that is abandoned after use or that is rejected, defective, whether or not it is intended for sale, recycling, reprocessing, recovery, or purification by a separate operation from the one that produced the matter. Waste management can be said as all actions and techniques required to handle the used and rejected items from production to its final disposal; these actions include collection, transport, treatment, recycling, and/or incineration.

The conceptual framework for waste management is made up of a set of indicators which are municipal waste generated & collected, hazardous waste generated & collected, municipal waste recycled, and hazardous waste incinerated (UNEP, 2017). These indicators give details on the types of waste generated, quantity, and means of handling (disposal or recycling) for the countries this report intends to examine. These indicators also tell how efficiently resources are being utilized. The present report intends to give details of these indicators for all the countries in the region. These details will provide the status of waste management as well as resource efficiency through recycling within the region. It is possible to do this via minimizing resource inputs, using resources in a circular manner, and recycling. Resource efficiency can be examined at the sectoral or overall economic level (UNEP, 2011). This is an important and useful concept that can be used to reduce waste production from its cradle stage and overall helping waste management. As previously stated, several countries in this region have begun to promote the collecting and sharing of knowledge on Environmentally Sound Technologies, with a particular emphasis on waste management, in order to maximize the use of their resources. The overall motive of educating the populace on proper waste handling is to gradually ease the efficient waste management which in turn enhances resource efficiency thus reducing environmental hazards which may result from this waste. The waste management data in this study were mainly sourced from UNEP (UNEP, 2021).

2.3.8 Trade dependency

Globalization has had a significant effect on trade and the environment (Cordero et al., 2004; Giljum and Hubacek, 2001). Developing countries have expanded their reliance on trade and embraced more liberal trade policies; but, as their reliance on trade grows, they must also regulate price volatility and productivity growth (Giljum and Hubacek, 2021). Hence, the international resource exchange has become more critical in economic growth through resource optimization. It is important to analyze a country's reliance on foreign trade including the country's import and export prices. These will help monitoring the patterns of the country's material exchange providing a comprehensive understanding of international material flows and supporting future policy decisions (Samaniego et al., 2017; Li et al., 2015). The Asia-Pacific region has increasingly become more dependent on natural resources than other regions. Two indicators have been selected to qualify the trade dependency.

The physical trade balance (PTB) is an important indicator for analyzing national material metabolism; it expresses whether the economies of countries/regions are dependent on resource inputs from other countries/regions (Giljum and Hubacek, 2001). To what extent is domestic material consumption based on domestic resource extraction and direct material input. Additionally, the population of country has been applied to PTB for showing the association between PTB and population size. The unit price of trade is another indicator that reports the relationship between how much money a country pays for its imports and how much it receives from its exports; it is directly related to unit prices for imports and exports of the country (UNEP, 2015b). The import and export volumes are classified into four main categories (MFA4). These categories have been further disaggregated into thirteen sub-categories (MFA13) which relates to all materials in the country as summarized in **Table 2**.

Table 2 Main categories and sub-categories for the material production sectors (CSIRO, 2018; Li et al., 2015)

Main categories	Sub-categories	Material Production Sectors
Biomass	Crops	Agriculture, forestry, animal husbandry and fishing, food and tobacco manufacturing, textile manufacturing, and so on.
	Crop Residues	
	Grazed biomass and fodder crops	
	Wood	
	Wild catch and harvest	
Metal ores	Ferrous ores	Metal ore mining, metal product manufacturing, metal smelting and rolling, and so on.
	Non-ferrous ores	
Non-metallic minerals	Non-metallic minerals - construction dominant	Nonmetal ore and other ore mining and processing, nonmetallic mineral product manufacturing, and so on.
	Non-metallic minerals - industrial or agricultural dominant	
Fossil Fuels	Coal	Coal mining and washing, petroleum and natural gas extraction, and so on.
	Petroleum	
	Natural Gas	
	Oil shale and tar sands	

2.3.9 Resources and human development

Human development is directly related to natural resource use and the emissions associated to them. It is because extraction and processing of natural resources, and the production and consumption of value-added products provide opportunities in the society to earn income. Therefore, it is necessary to observe the impacts of decoupling (separating natural resource use from economic growth) on the human development in the economies.

In the UNEP 2015's report, Gini Index, middle class consumers, Poverty Index, economic growth (GDP), and Human Development Index (HDI) were suggested as complementary indicators to those presented under other regional indicators (material use, water use, energy use etc.). However, HDI was the only indicator used in the previous UNEP 2015's report. The present report will also incorporate only HDI. The reason for not using the Gini Index and

Middle Class Consumer is severe data limitations. The conventionally used poverty index was the Human Poverty Index (HPI) which was replaced by the Multidimensional Poverty Index (MPI) in 2010. Both the HDI and the MPI address the same three main aspects of human development: health, education, and standard of living. The distinction between these two indicators is that HDI uses aggregate-level indicators, whereas MPI employs micro-level data. The first fundamental criterion for MPI is that all data for people or households come from the same survey. This is to determine whether a person is deficient in a variety of areas. Thus, it is not possible to collect indicators from diverse data sources — for example, it is not possible to use health data from one source and education data from another, as it is with HDI (HDRO, 2015). Due to the data limitations, MPI will not be used in the present report. HDI can be calculated by taking weighted average of literacy rate, life expectancy ratio, and GNI per capita. In the UNEP 2015's report, the HDI values were for 1990 – 2010. So, in this new report, the HDI values for 2010 – 2017 are presented. The data have been obtained from UNEP (UNEP, 2021) and the World Bank (World Bank, 2021).

Investment and consumption

The deployment of present financial resources in order to achieve larger long-term benefits is referred to as investment. It can also be defined in economic terms as the value of fixed capital assets (and stocks) created over a given time period, as well as the development of capital commodities. Investment proves to be a shot in the arm for the income cycle. Consumption, on the other hand, refers to the total amount spent on goods and services to meet needs during a given time period. In economics, it refers to the flow of household spending or commodities and services that provide utility in the current period, as well as the usage of goods and services by households.

Domestic material consumption per capita and foreign direct investment were the two indicators considered in the analysis. The data for foreign direct investments came from the World Bank databank, and net flows were measured in terms of GDP percentage. Foreign direct investments are the investment in which the direct venture equity flows in the reporting economy. The sum of equity capital, earnings reinvestment, and other capital is the total capital. A sort of cross-border investment in which the investor is a resident of one country is known as direct investment. An updated dataset is required for foreign direct investment as data is available until 2019. A sector-based classification of investments may also provide useful information.

Debt, inflation

The overall incurred external financial obligations that are accumulated to finance expenditures above the generated revenues are referred to as the general government gross debt. Inflation, on the other hand, is the price hike in an economy over a specific period of time. Due to the obvious increase in overall prices, the currency unit can buy fewer products and services, indicating a decrease in purchasing power. Ultimately, it leads to a loss of real value in the economy's medium of exchange and unit of account. Therefore, both indices (i.e., debt and inflation) are very significant to assess the economic conditions of any nation.

For this purpose, two indicators have been used to analyze the economic performance of selected nations in the Asia Pacific region: the general government debt (expressed in terms of percentage of the GDP) and inflation rate (expressed in terms of annual percentage change in average consumer prices). The data for both indicators were retrieved from the International Monetary Fund (IMF) database (IMF, 2021).

2.3.10 Inclusive green recovery

The pandemic crisis, staged by the nature, is expected to be an opportune time to put forward the sustainable development agenda in front of the civilized and modern world. There are a few lessons the world has been learning from the COVID-19 crisis. Primarily, our planet has certain thresholds on which nature operates, and there are grave consequences if these are not respected. As the limits has already been pushed up to the extremes, nature reacted in terms of the pandemic and left the world devastated. The second and the most important lesson arose in terms of hope that a revived and sustainable liaison with nature is feasible. However, a strong commitment and collective measures are required for recovery.

Depending upon the perspectives, requirements, and capacities, each policy design and uptake will vary substantially among the nations in Asia Pacific region. However, in this report, special attention is paid to the stimulus packages or financial support dedicated to recover from the COVID crisis. The COVID spending (in terms of key fiscal measure by the governments), natural capital (in terms of natural capital per capita), and green spending (in terms of energy, transport, buildings, and green research and development) are the key indicators chosen to analyze the status quo of the Asia Pacific region. Therefore, effects of the pandemic on natural capital and natural budget in the region can be highlighted. Furthermore, green building development or upgradation approaches may also prove to be effective tools for policy makers to deal with economy, pandemic, and environment simultaneously. However, the data related to the green buildings is missing for the Asia Pacific region.

COVID spending

For the Asia Pacific region, the required dataset of COVID spending was retrieved from the International Monetary Fund (IMF) database. Furthermore, it also summarizes the key fiscal measures taken by governments in response to the pandemic. The retrieved data not only categorizes different types of fiscal support provided in terms of equity, loans, and guarantees, but also specifies the additional spending or forgone revenues, which consists of temporary tax cuts and liquidity support from the public sector, including loans, guarantees, and capital injections.

Natural capital

Natural capital per capita is the carefully chosen indicator selected for the assessment of natural capital in the Asia Pacific region. The dataset was retrieved from the Wealth Accounts - World Bank Databank. This indicator incorporates the valuation of fossil fuel energy (oil, gas, hard and soft coal), minerals (bauxite, copper, gold, iron ore, lead, nickel, phosphate, silver, tin, and zinc), agricultural land (cropland and pastureland), forests (timber and some nontimber forest products), and protected areas. Values are calculated using a country-specific GDP deflator at market exchange rates in constant 2014 US dollars.

Green spending

The Global Recovery Observatory tracked every individual COVID-19-related fiscal spending policy proposed by the world's main economies. The observatory's spending data focuses on 'recovery' spending as opposed to 'rescue' spending. On the official website of the Global Recovery Observatory, each policy and its relative 'greenness' based on potential impact on long- and short-term GHG emissions, air pollution, natural capital, quality of life, inequality, and rural livelihood can be further explored. Furthermore, different sectors (i.e., energy, transport, buildings, and green research and development) are also explored in green recovery perspective.

Green energy investments

Green energy comes from natural or renewable resources; therefore, it has less environmental impacts leading to a cleaner and more sustainable energy. Green energy investments have high potential to attract the private investors and play a crucial role in economy-wide decarbonization. New renewable generating, transmission investments, distribution (including smart grids), and energy storage options can all provide significant benefits. When compared to typical energy programs, employment prospects for these investments can be substantial, particularly in the short term (Dvořák et al., 2017).

Green transport

Effective and environmentally friendly travelling methods with less emissions, pollution, and consumption is the simplified concept of green transportation. Transportation is one of the major components of current GHG emissions; therefore, decarbonizing the sector is crucial for meeting climate targets. These investments can take many forms. For instance, the subsidies provide the facility to transfer from conventional to electric vehicles and financing the charging infrastructure are one of the most common investment forms in 2020. This approach could help not only reducing energy consumption but also improving air quality and health status. Many jobs can be created quickly through green transportation investments, which may help to bring high economic benefits (Unsworth et al., 2020). Two indicators were selected to analyze the status quo of the transport sector in green perspective: electricity demand from the global EV-fleet and biofuel production in 2019 compared to their consumption in 2030 under the sustainable development scenario. The data was retrieved from the International Energy Agency (IEA) data bank.

Green research and development

Longer-term stimulus plays a role in any economic recovery package. Furthermore, the long-term and short-term acting measures can be combined to ensure the economic growth. Rather than simply moving future demand backwards, it may help expedite investment in order to create new long-term demand and industrial capability. Green R&D policies could be critical to achieving the 2030 Sustainable Development Goals (SDG goals no. 7, 9, 11, 12, and 13). The indicator 'Dollar value of financial and technical assistance committed to developing economies' is the selected to assess the green research and development in the Asia Pacific region. The dataset is retrieved from the Asian Development Bank-Key Indicators Database. This indicator is in accordance with the SDG Target 17.9: Enhance international support for implementing effective and targeted capacity-building in developing economies to support national plans to implement all the Sustainable Development Goals, including through North-South, South-South, and triangular cooperation.

Chapter 3 Regional resource efficiency indicators

3.1 Natural resources

Materials, energy, water and land are considered as main resource uses, thus emissions, impacts and waste related to these resource uses are taken into consideration. As agricultural sector is a key significant sector in the Asia Pacific region, so that a focus is placed on the productivity of this sector. With regards to emissions, impacts and waste, greenhouse gas emissions and waste management are selected to represent those aspects. Hence, material use, renewable energy use, water use, land use, agricultural productivity, greenhouse gas emissions, and waste management are selected as regional resource efficiency indicators by means of natural resources.

3.1.1 Material use

Consumption and production are essential to economic activities, but they can also contribute to the depletion of natural capital if they are not handled properly. Therefore, out of the 17 United Nations Sustainable Development Goals (SDGs), one goal is dedicated to ensuring sustainable consumption and production (SDG 12). The main aim of this goal is to encourage sustainable consumption and production by reducing natural resource exploitation, reducing the use of harmful materials, and relying on production practices that produce less pollution and generate less waste. The region has surpassed the others in terms of natural resource consumption as well as the production (i.e., the biggest producer in the world) (Institute for Global Environmental Strategies, 2010). In this section, 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 in the Asia Pacific developing countries. Further, the material use is classified into four main material categories and 13 subcategories as shown in **Table 3**. The time series here covers the period 2010 to 2017.

Table 3 The four categories of materials included in domestic material consumption, with decomposition into 13 subcategories

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

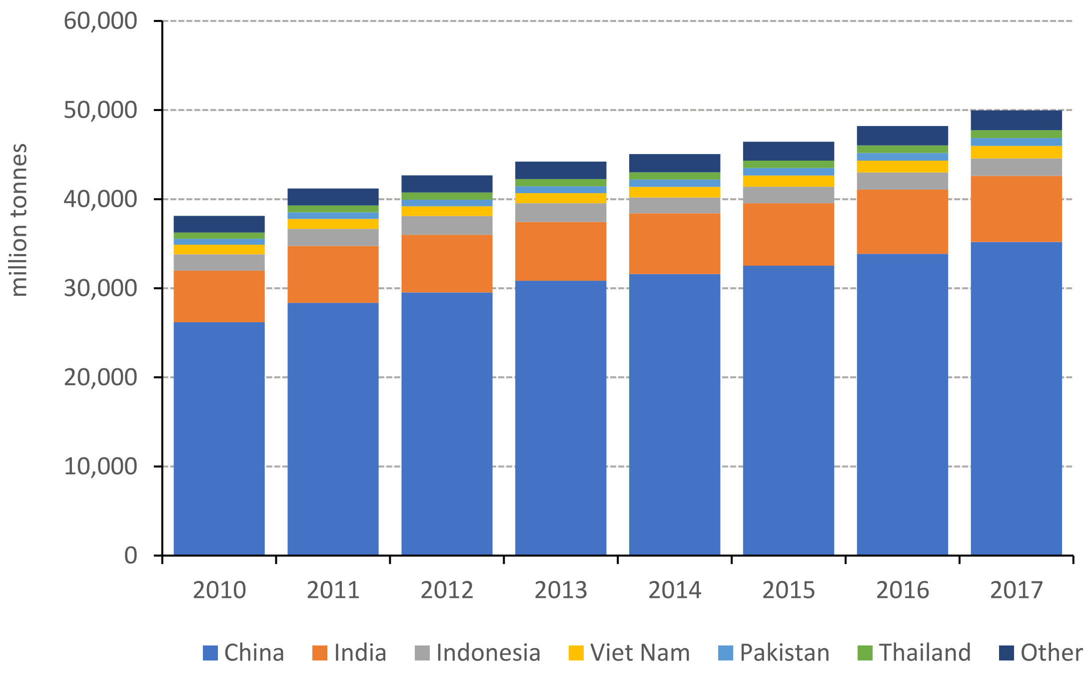


Figure 6 Domestic material consumption, the Asia Pacific region (2010 – 2017)

As presented in **Figure 6**, the total DMC in the Asia Pacific developing region has increased from 38 billion tonnes to around 50 billion tonnes in just seven years from 2010 to 2017. **Figure 6** shows the DMC of the Asia Pacific countries from 2010 to 2017, separating out the six with the highest DMC. The average annual share of these six Asia Pacific countries in the regional total DMC was around 95%. China has the highest annual DMC in the whole region followed by India. The overall regional DMC increased at a growth rate of 3.4% per annum; China's and India's DMC grew at a rate of 3.8% and 3.1% per annum, respectively.

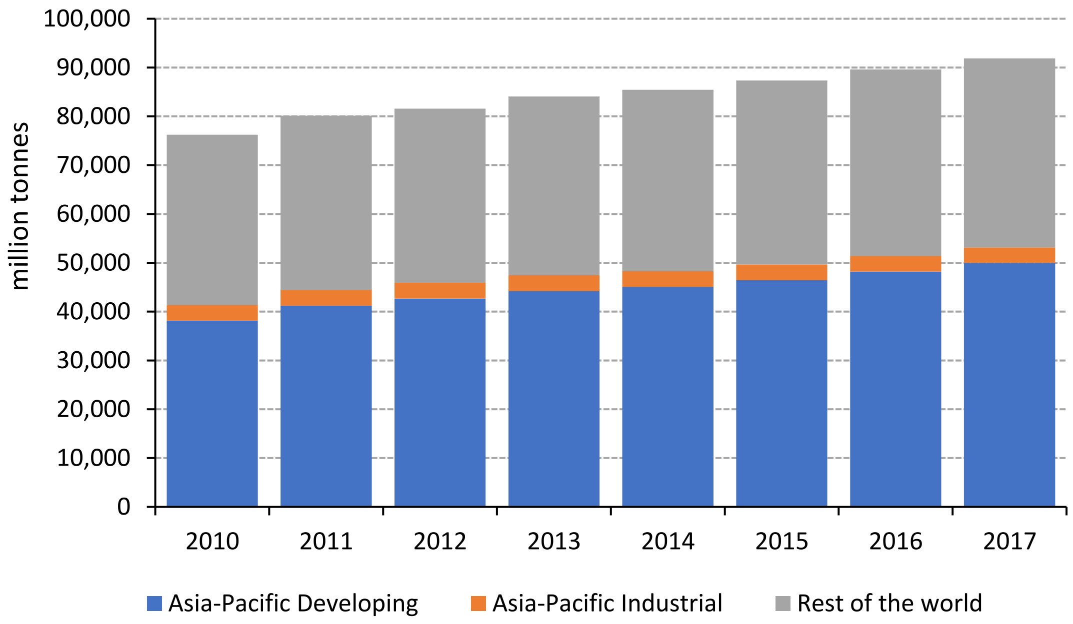


Figure 7 Domestic material consumption, the Asia Pacific region, and rest of world (2010 – 2017)

Figure 7 shows the regional growth in DMC for the Asia Pacific developing, Asia Pacific industrialized, and the rest of the world over the period 2010 – 2017. The regional average annual growth in DMC for the Asia pacific developing region was 3.4% as compared to the rest of the world which only increased by 1.3% over the same period. The regional share of the Asia Pacific developing countries in global annual DMC increased from 50% in 2010 to around 54% in 2017. On the other hand, the regional average annual growth in DMC for the Asia Pacific industrialized countries decreased at an average rate of 0.15%. It showed that industrialized countries in the Asia Pacific region are adopting sustainable consumption and production patterns unlike the Asia pacific developing countries which are also increasingly dominating the global material consumption and growing most rapidly.

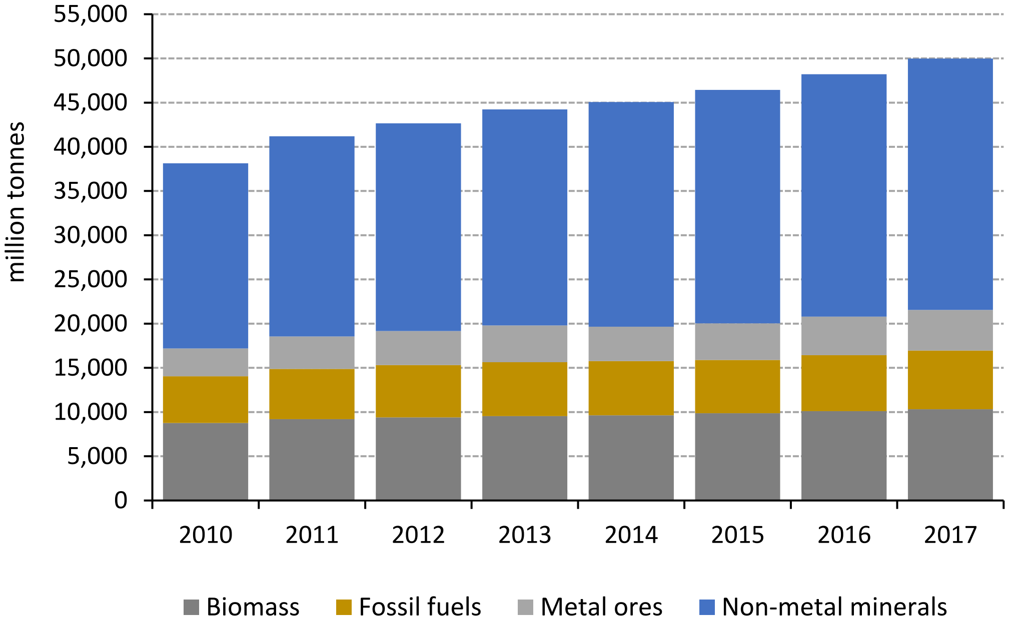


Figure 8 Domestic material consumption by material category, Asia Pacific developing countries (2010 – 2017)

Figure 8 presents the category-wise DMC in the Asia Pacific developing countries. 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, metal ores, and non-metal minerals for Asia Pacific developing countries has increased at a rate of 2.1%, 2.9%, 4.8%, and 3.9%, 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 percentage growth in metal ores is more than twice as compared to biomass and around 65% higher than fossil fuels. Moreover, the share of each material category in the total annual consumption has decreased for biomass and fossil fuels from 23.0% in 2010 to 20.7% in 2017, and from 13.8% in 2010 to 13.3% in 2017, respectively. On the other hand, it has increased for metal ores and non-metal minerals from 8.3% in 2010 to 9.2% in 2017, and from 54.9% in 2010 to 56.9% in 2017, respectively. These statistics indicate that the economies in the Asia Pacific developing region are moving away from the biomass-based materials and energy systems and adopting the mineral-based systems of industrial economies. The different growth patterns of the different material categories exhibit that economies in the Asia Pacific developing region are undergoing a transition from advanced agrarian economies to industrialized societies.

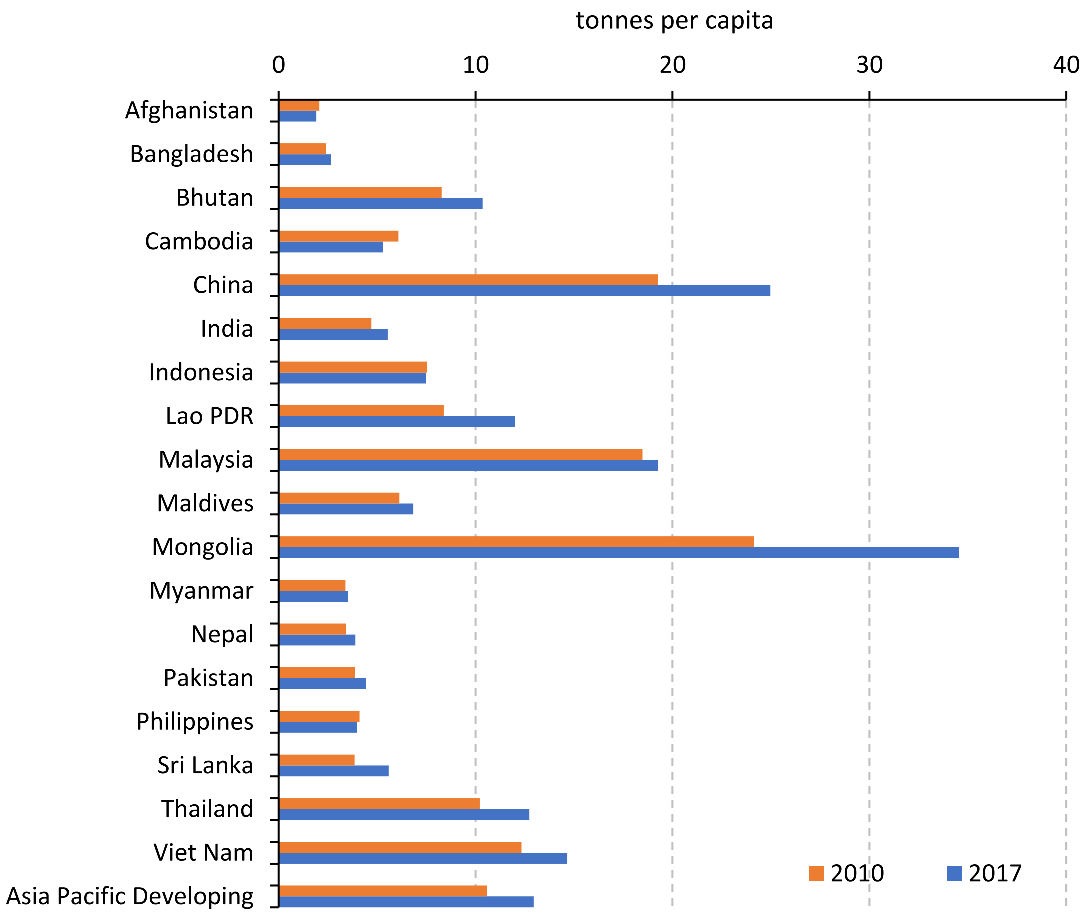


Figure 9 Domestic material consumption per capita, Asia Pacific developing countries (2010 – 2017)

Figure 9 shows the DMC per capita (tonnes per capita) of the Asia Pacific developing countries as an increase in DMC would be expected due to the increase in industrial development. The highest increase in DMC per capita from 2010 to 2017 was observed in Mongolia from 24.2 to 34.5 tonnes/capita, followed by China, Lao PDR, Thailand, Vietnam, and Bhutan as 19.3 to 25.0, 8.4 to 12.0, 10.2% to 12.7, 12.3 to 14.7, and 8.3 to 10.4 tonnes/capita, respectively. On the other hand, some countries, viz., Indonesia, the Philippines, Afghanistan, and Cambodia have shown a decrease in DMC per capita from 2010 to 2017 as 7.54 to 7.48, 4.11 to 3.97, 2.07 to 1.91, and 6.08 to 5.29 tonnes/capita, respectively. This decrease in DMC per capita of the above-mentioned countries is due to the rapid rate of population growth in these countries. Despite the two different growth trajectories for the different groups of economies in the Asia Pacific developing region, the overall regional DMC per capita has increased from 11.0 in 2010 to 12.2 in 2017as presented in **Figure 9**.

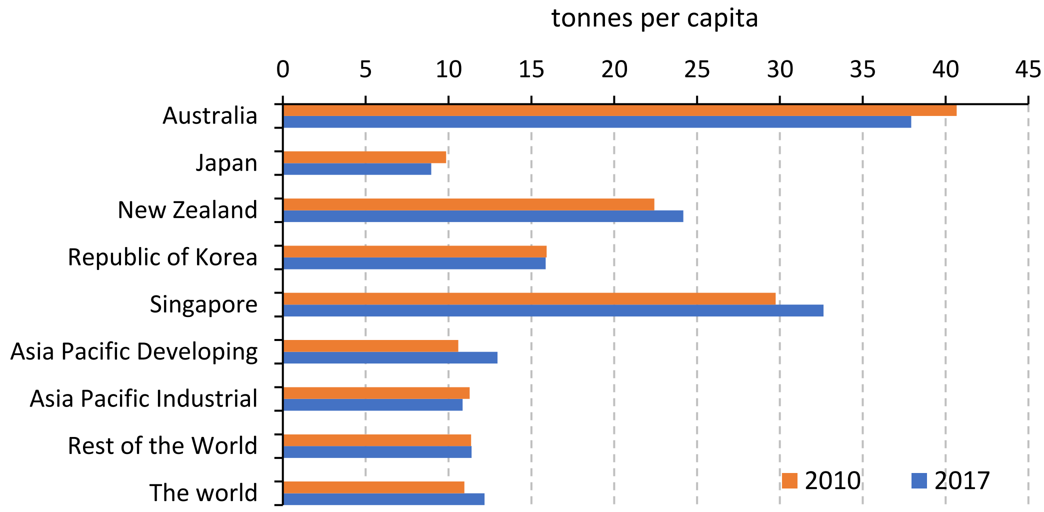


Figure 10 Domestic material consumption per capita, Asia Pacific industrialized countries (2010 – 2017)

Figure 10 shows the patterns of DMC per capita of the Asia Pacific industrialized countries. From 2010 to 2017; the DMC per capita for two out of the five, viz., Australia and Japan decreased from 40.67 to 37.93 tonnes/capita and from 9.86 to 8.96 tonnes/capita, respectively, while that for New Zealand and Singapore increased from 22.42 to 24.17 tonnes/capita, and 29.75 to 32.63 tonnes/capita, respectively. Republic of Korea's DMC per capita in 2017 was 15.92 tonnes/capita which was almost the same as in 2010. Even though Australia's DMC per capita decreased, it remained the highest followed by Singapore, New Zealand, and the Republic of Korea. In 2017, Japan had a DMC per capita of 8.96 tonnes/capita which was the lowest among the Asia Pacific industrialized countries. Moreover, Japan's DMC per capita was even lower than the overall Asia Pacific Industrialized region as well as the global DMC per capita which were 10.85 and 12.17 tonnes/capita, respectively. It shows that Japan has adopted the pattern of sustainable production and consumption and moving towards decoupling by consuming a modest quantity of material and providing the highest level of living standards in the society.

3.1.2 Renewable energy use

The indicator renewable energy share in total final consumption, which is the percentage of final energy consumption derived from renewable resources, is used to measure renewable energy use. The main sources of renewable energy include hydro, wind, solar, solid biofuels, liquid biofuels, biogas, geothermal, marine, and waste sources. Solar energy (e.g., solar PV and solar thermal); liquid biofuels (e.g., bio-gasoline, biodiesels, and other liquid biofuels); and solid biofuels (such as fuelwood, animal waste, vegetable waste, black liquor, bagasse, and charcoal) are some of the specific renewable energy sources. The renewable energy share in the total final energy consumption is measured in terms of percentage. However, for renewable energy use, a more updated dataset is required as the data presented for energy use is just for the years between 2000 to 2018. Furthermore, sector-based consumption data which may provide more insights on resource efficiency is also missing.

In the last two decades, a decreasing trend in renewable energy share in the total final energy consumption can clearly be observed in the Asia Pacific region. However, renewable energy share in the total final energy consumption of the world has not changed very much (i.e., just 17.25% in 2000 to 17.11% in 2018). On the other hand, the decline is very swift in case of the Asia Pacific region (i.e., from 39% to 23% from 2000 to 2018) as shown in **Figure 11**. Most of the countries in this region (except Afghanistan, Malaysia, and China) decreased the share of renewable energy in the final energy consumption since 2010, as shown in **Figure 12**.

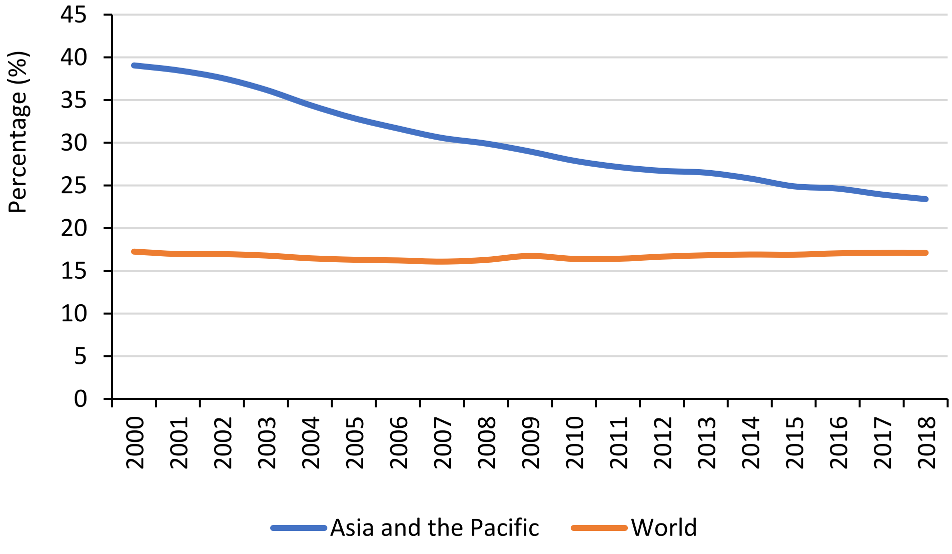


Figure 11 Renewable energy share in the total final energy consumption, Asia Pacific region, and World (2000-2018)

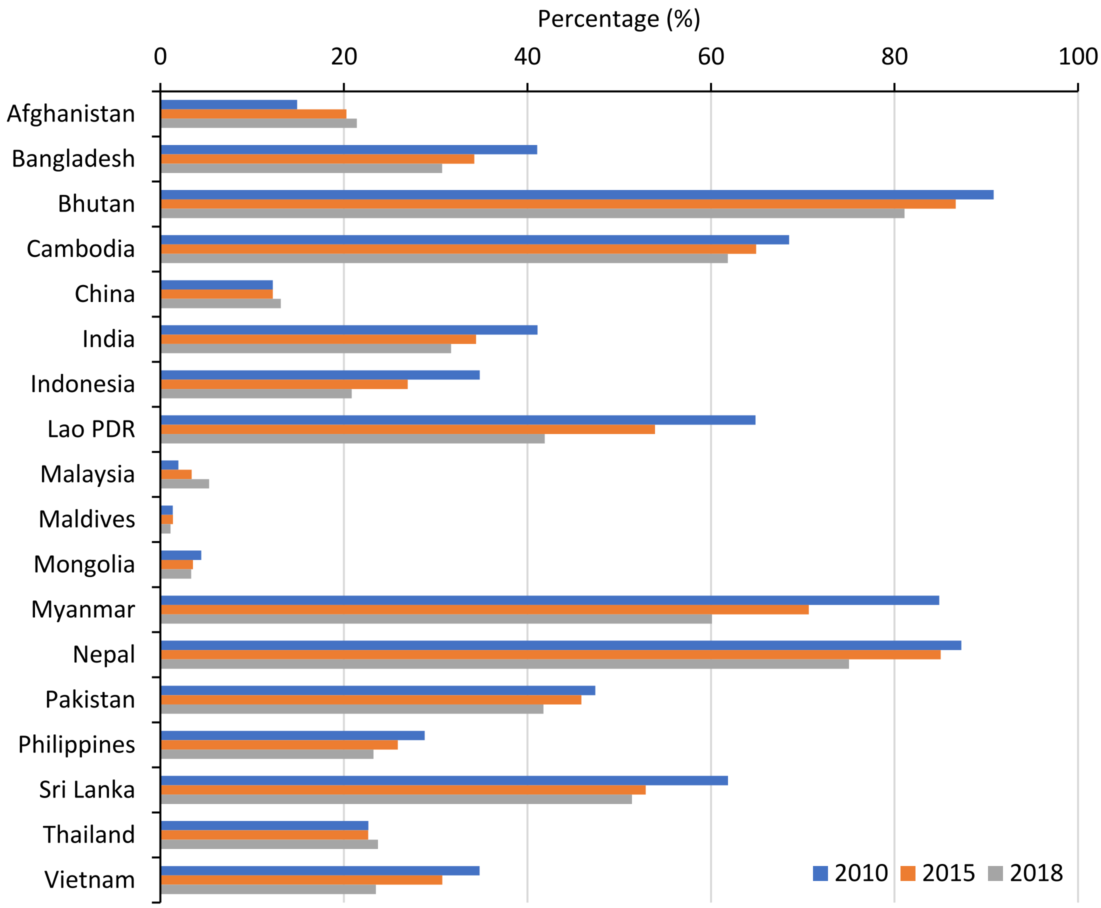


Figure 12 Renewable energy share in the total final energy consumption, the Asia Pacific developing countries

3.1.3 Water use

In terms of quantity, water is the largest resource used in economic production, which is more than three quarters. As industrial progress is linked with GDP growth, that puts further pressure on water resources even after the decoupling efforts (UNEP, 2015b). It can be summarized that the agriculture sector is the main water user followed by the domestic and industrial sectors which share an equal rank. Secondly, the deprivation of freshwater may damage human health, ecosystem quality, and freshwater resources (Pfister et al., 2009).

Total water withdrawals

Total freshwater abstractions for use in agriculture, industry, and the residential sector, from all surface and subsurface sources, are reported in this indicator. However, direct rainfall on crops is not taken into account. The Food and Agriculture Organization of the United Nations

(FAO) provided the baseline statistics for annual total water withdrawals. FAO provides the water withdrawal data in terms of volume per year after every four years. Therefore, the missing data was generated through linear Interpolation technique (Noor et al., 2013). The seven countries with the highest water withdrawals in the Asia Pacific region in 2017, are shown in **Figure 13**. The top seven water withdrawing countries also have huge agricultural land use indicating that the main source of water withdrawal was agricultural activities. Between 2010 and 2017, the total water withdrawal in the Asia Pacific countries increased by 65 billion cubic meters. The increase in water withdrawal can be because of multiple reasons, viz., the increase in population, expansion in agricultural land use, and increase in industrial activities. However, the rate of increase of regional GDP is higher than the rate of increase of water withdrawal which may reflect the decoupling of efforts of the nation's due to improvement in irrigation techniques, etc. However, the agriculture sector is the dominant sector in exports of most of the Asia pacific countries' economies. Therefore, Asia Pacific Region also withdraws water to produce goods for other countries. SCP HAT tool provides the data of blue water use of the country that is used to produce products for other countries.

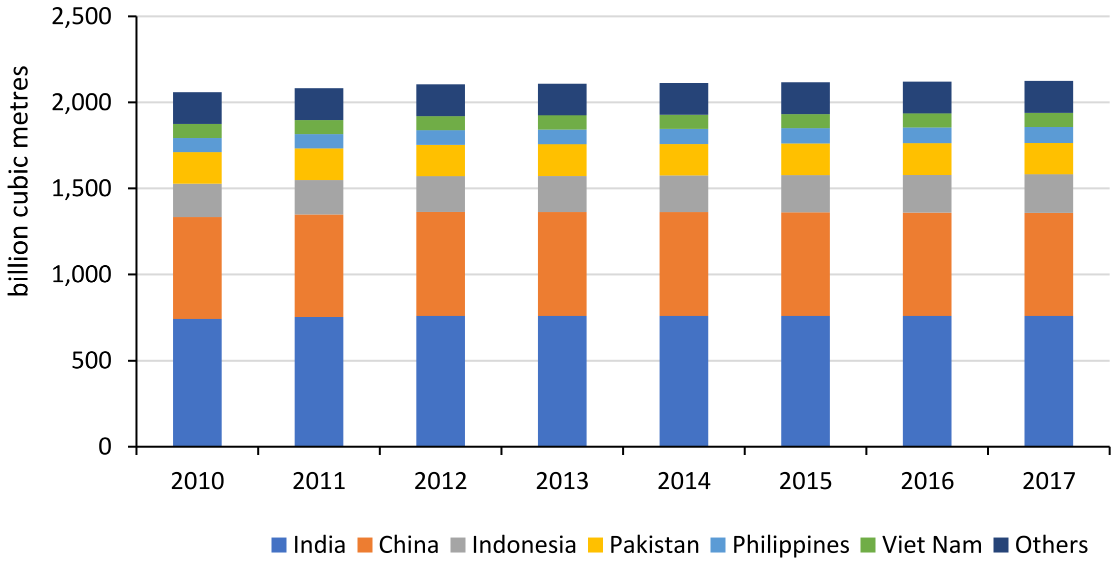


Figure 13 Total water withdrawals, Asia Pacific region (2010 – 2017)

Water withdrawals, by sector, in the Asia Pacific region

The sectoral (agriculture, domestic, and industry) distribution of water withdrawal for each country under investigation for the year 2015 is shown in **Figure 14**. The agriculture sector is the dominant sector for water withdrawal for all the countries except the Maldives. For the

Maldives, water withdrawal for agriculture is the least because relatively no land is available for agriculture. Water withdrawal for the agriculture sector is more than 80% for thirteen out of 18 countries because of their dependence on agriculture. The water withdrawals of both domestic and industrial sectors are relatively low.

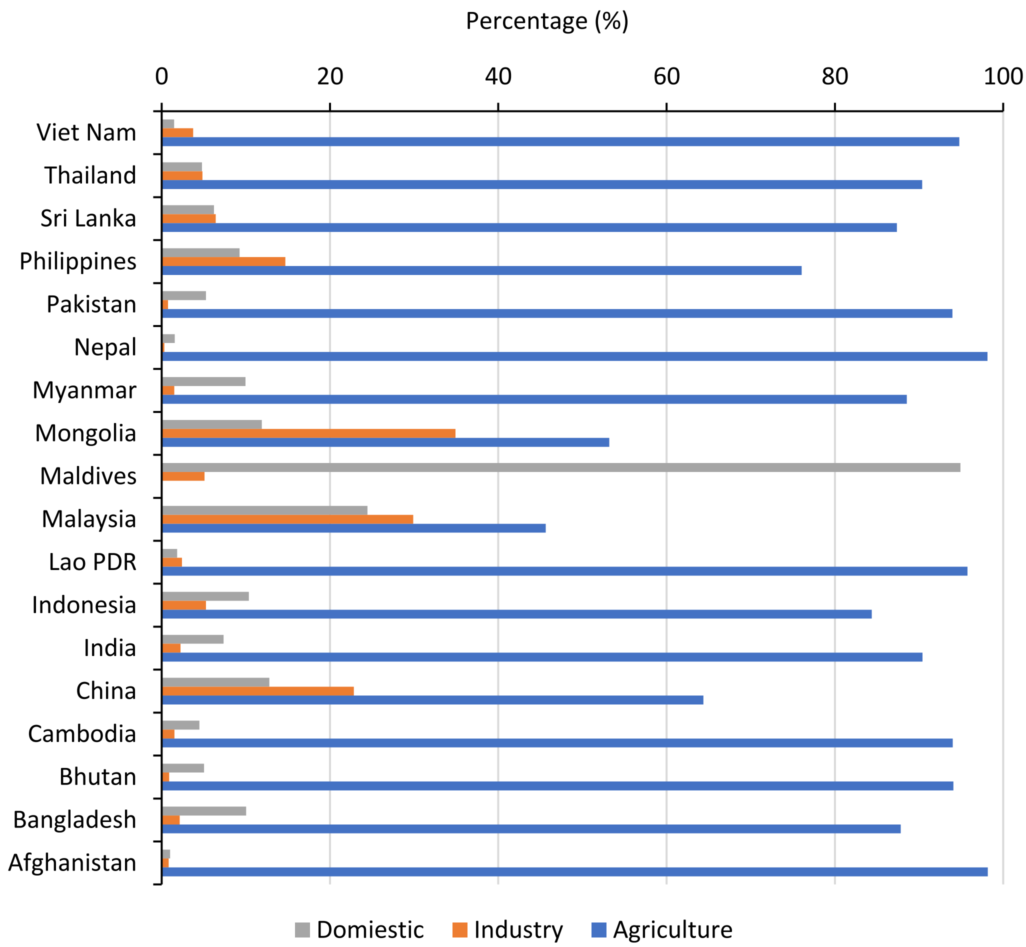


Figure 14 Water withdrawals, by sector in the Asia Pacific region (2015)

Water withdrawals per capita

It measures the ratio of total water withdrawal to the total population of the nation. Water withdrawal per capita for the 18 countries were assessed for the year 2010 and 2017 as shown in **Figure 15**. Water withdrawal per capita for all the countries was decreasing except for a couple of countries (Indonesia and Lao PDR), while no change was noticed for China. The highest decrease was noted for Pakistan by 15 % from 2010 to 2017. The increase in water withdrawal for Lao PDR and Indonesia may be due to the development of water-intensive industries such as mining, etc. The second reason may be the increase in the number of reservoirs for water storage. Lao PDR is developing many new hydropower and irrigation dams. On the other hand, a decrease in water withdrawal per capita may be due to the depletion of water resources or leading towards water scarcity. It may also be because of increase in water resources cannot keep up with the increase in population.

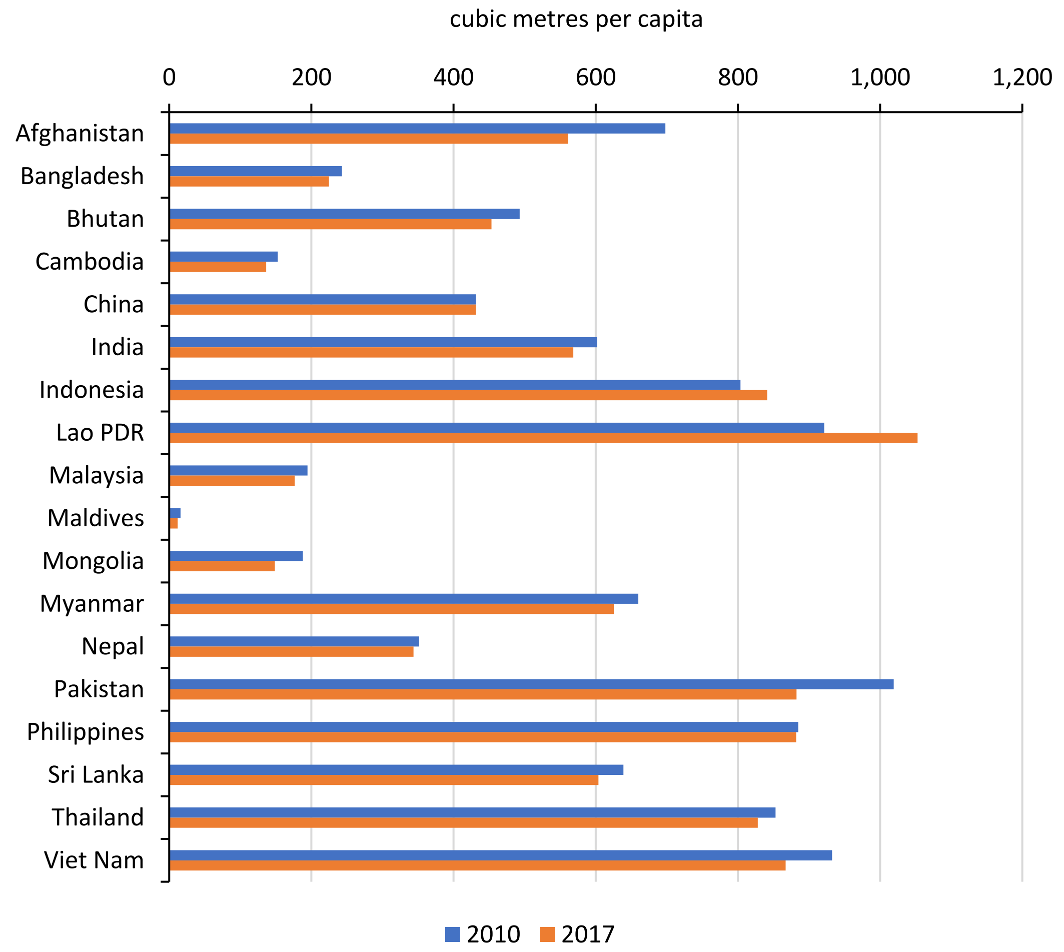


Figure 15 Water withdrawals per capita, Asia Pacific developing countries (2010, 2017)

Agricultural water withdrawal

Agriculture is by far the largest user of water, accounting for 70 % to 80 % of total water resources. Many Asian developing countries rely on agriculture for food security and export opportunities. The measure of water used is "agricultural water withdrawal", with base data drawn from FAO. The seven countries with the highest agricultural water withdrawals in the Asia Pacific region (2010 – 2017) are shown in **Figure 16**. India withdraws the highest water for agriculture among all under investigation, which is almost 40 % of the total in 2017. China, India, and Indonesia are the top three water withdrawing nations as also the top three countries having the most agriculture land use. However, China has the most land use under agriculture, but its water withdrawal is lower than India. It may be due to the more efficient irrigation system in China or may be due to the difference in crop water requirement.

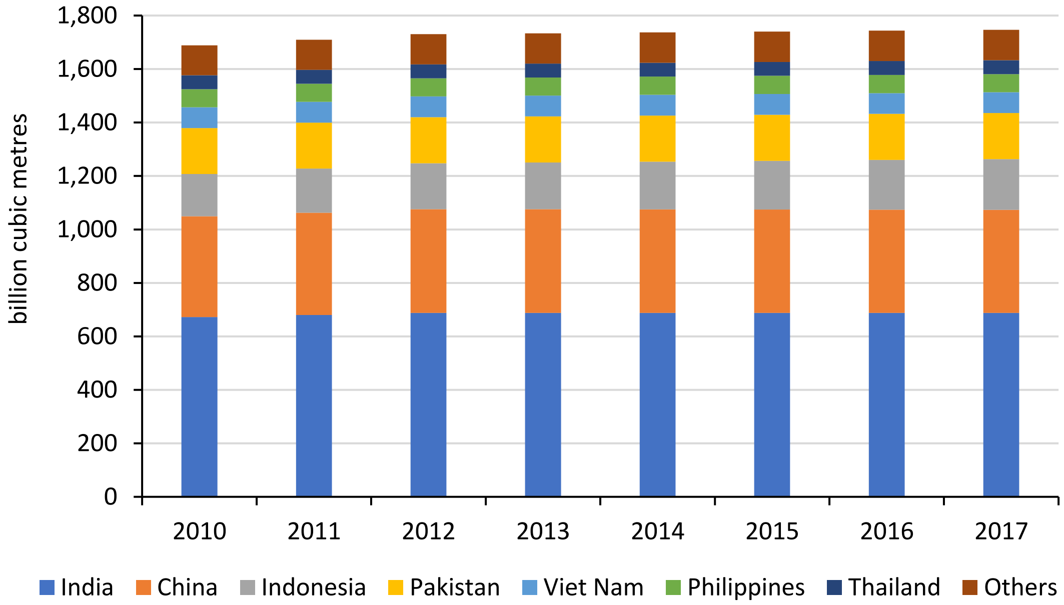


Figure 16 Agricultural water withdrawal, Asia Pacific region (2010 – 2017) (EDGAR, 2019)

3.1.4 Land use

Human progress has grown at an ever-increasing rate in modern history. As a result, remarkable shifts in land use have been seen (Roser, 2014; Winkler et al., 2021). More than 50% of Asian land area is under agriculture. Agricultural expansion is Asia's most prevalent anthropogenic land change activity; as the total area of agricultural land in South and Southeast Asia rose by 296 and 1275 %, during 1700 to 1980, respectively (Meyer, 1996). This expansion is being driven by increases in population, GDP, and food demand. Many of the world's tropical rain forests and subtropical mountain forests are found in Asia. Between 1850 and 1978, over 1.2 million km^2 of forest area in Asia were cleared (Zhao et al., 2006). According to an assessment conducted in 2005, the forests of the Asia Pacific cover around 26 % of the land area in the region (FAO, 2005). Southeast Asia has the highest pace of tropical deforestation of any major tropical region. Deforestation on a large scale has happened in Asia, mostly because of agricultural expansion and wood extraction.

The 60% of the global population resides in Asia Pacific region and Asia has the world's highest concentration of megacities. In 2017, 21 of the world's 35 megacities situated in Asia Pacific (UNDRR, 2020). The transformation of agricultural land to urban land has been particularly noticeable. Summer temperatures, nighttime temperatures, and water quality have all worsened as a result of urbanization (Zhao et al., 2006). Overall, changes in land use and land cover (LULC) may lead to multidimensional issues (Winkler et al., 2021). In short, agriculture, forestry, and urban land areas are the major landholding sectors in the Asia Pacific region. Forest cover is changing into agricultural land, and agricultural land is converted into an urban area.

Total Land Use in the Asia Pacific region

Biologically productive land areas play a vital role to provide the resources to the population for consumption, and to absorb its wastes (Global Footprint Network, 2021). Therefore, the total land use is measured by calculating the amount of biologically productive land of each country, which is comprised of agriculture, forest, and built-up area. These land use classes (agriculture, forest, and built-up area) are mainly responsible for resource consumption and production. The remaining area of each country is classified as “Others”. The “Others” land use class was not included in the total land use because this land use class is very less productive or not productive. It consists of bare land, snow area, water bodies, grassland, and shrubland area. The spatial distribution of each land use class in the Asia Pacific is shown in **Figure 17**, for the years 1992 and 2015.

From 1992 to 2015, land use data were downloaded from the European Space Agency portal and processed in ArcGIS. In twenty-four years (1992 – 2015), land occupied by agriculture and built-up areas has increased by 12 and 13 million hectares, respectively. However, nearly eight and half million hectares of forest have been lost from 1992 to 2015. Total land use in million hectares of the Asia Pacific region from 1992 to 2015 is shown in **Figure 18**. Total land use of the Asia Pacific region from 1992 to 2015 has increased by nearly 17 million hectares. The increase in total land use (biological area) of the Asia Pacific countries can be due to the increase in economic activities. In other words, the increase in total land use is maybe because of agriculture expansion to meet the food requirement of the increasing population. Secondly, the urban expansion may also be a contributing factor because of the increase in per capita income that can lead to the change in lifestyle, especially in the case of rapidly growing economies.

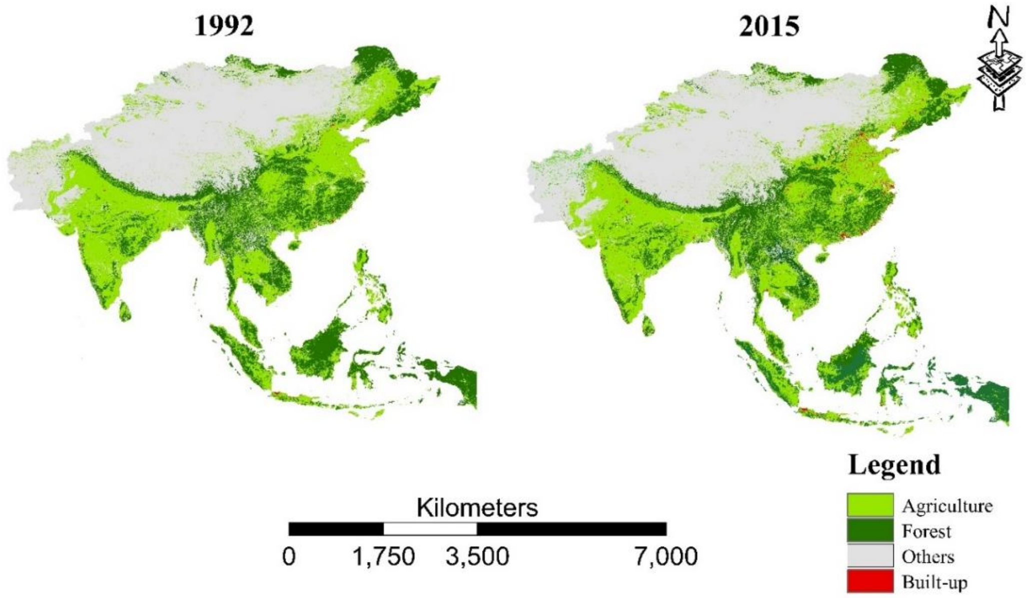


Figure 17 The spatial distribution of each land use class in Asia Pacific (1992 and 2015)

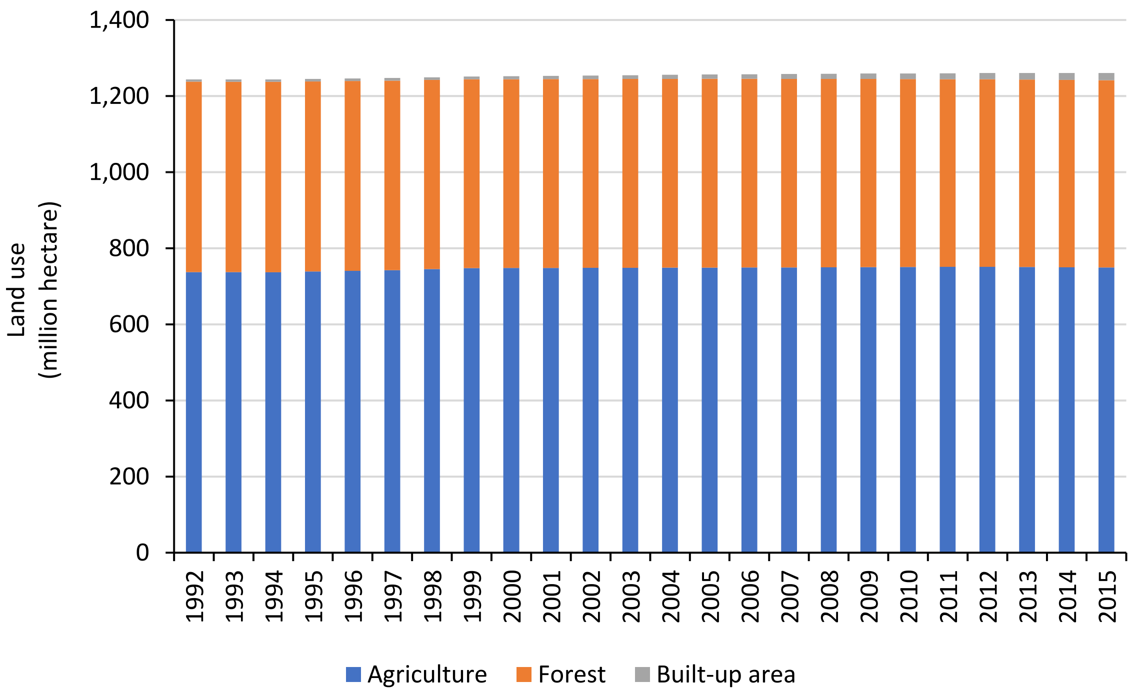


Figure 18 Total land use (urban, forest, agriculture) area of Asia Pacific region (1992 – 2015)

Land use per capita in the Asia Pacific region

The land use per capita is a nation's total land use (agriculture, forest, and built-up area) divided by the total population of the nation. The land use per capita is showing a decreasing trend for all the countries under consideration from 1992 to 2015 (**Figure 19**). The highest change in land use per capita was observed in Mongolia at 6.487 ha/capita in 2015, the lowest in the Maldives at 0.014 ha/capita. The decrease in land use per capita is indicating that the use of land as a resource does not increase as much as the population. Secondly, it also may be due to the efforts of all the nations to improve their land efficiency by improving the agricultural yields through different means and expanding the megacities in a vertical manner as well.

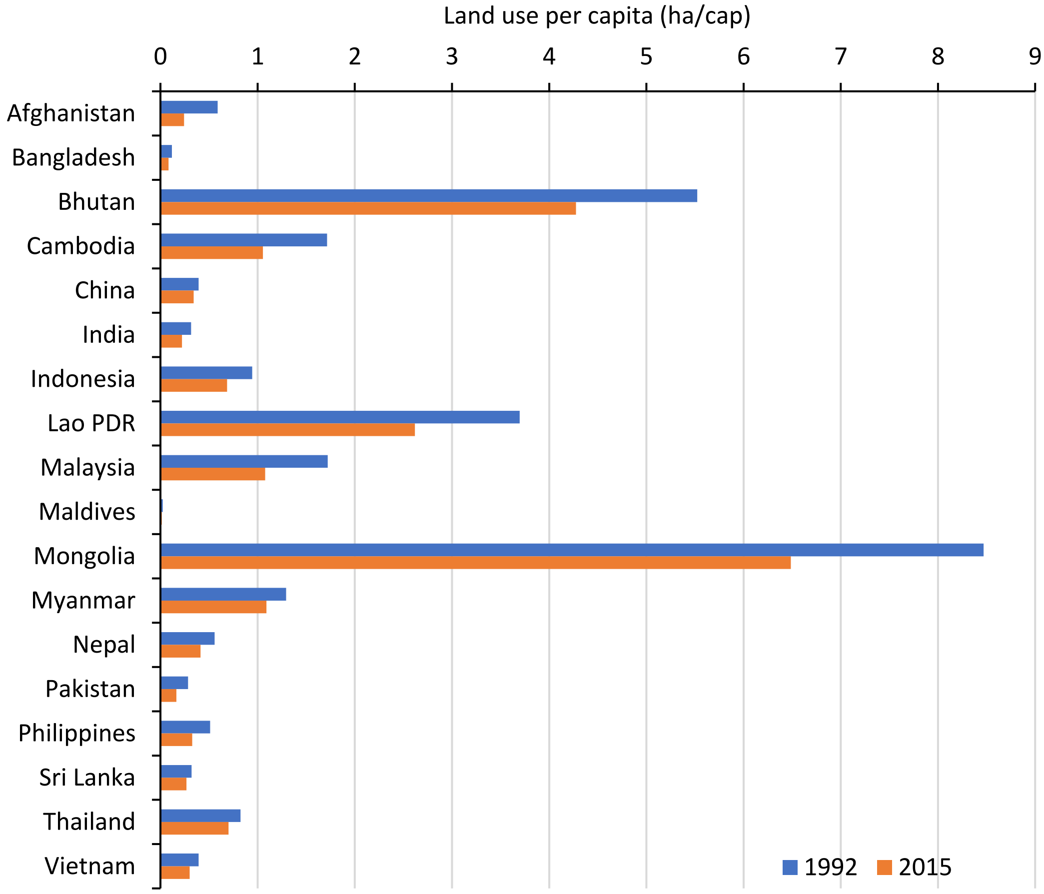


Figure 19 Total land use (urban, forest, agriculture) per capita of Asia Pacific region (1992 – 2015)

Land use of each country was divided into four sectors, viz., Agriculture, Forest, Built-up, and Others. The first three sectors were considered in this investigation because they play significant role in economy. However, the others land use consists of bare land, snow area, water bodies, grassland, and shrubland areas. The contribution of others land use type, especially grassland, to the economy is very low (Rae, 2002). In this section, agriculture is the leading sector of land use in almost all the countries under investigation except Cambodia, Indonesia, and Myanmar. Land use area by sector in the Asia Pacific region for the year 2015 of each country under consideration is shown in

Figure 20. Forest land is in second place in terms of area in the Asia Pacific region. China, Indonesia, and India are the top three countries having the most forest cover among the countries under consideration. These three countries combined represents more than 70% of forest cover in the Asia Pacific. Urban land use is the least in terms of area. China's urban land use alone contributes more than 60% of the total urban land use in the Asia Pacific. Urban land contributes the most to a nation's economy in terms of economic value generated per unit area.

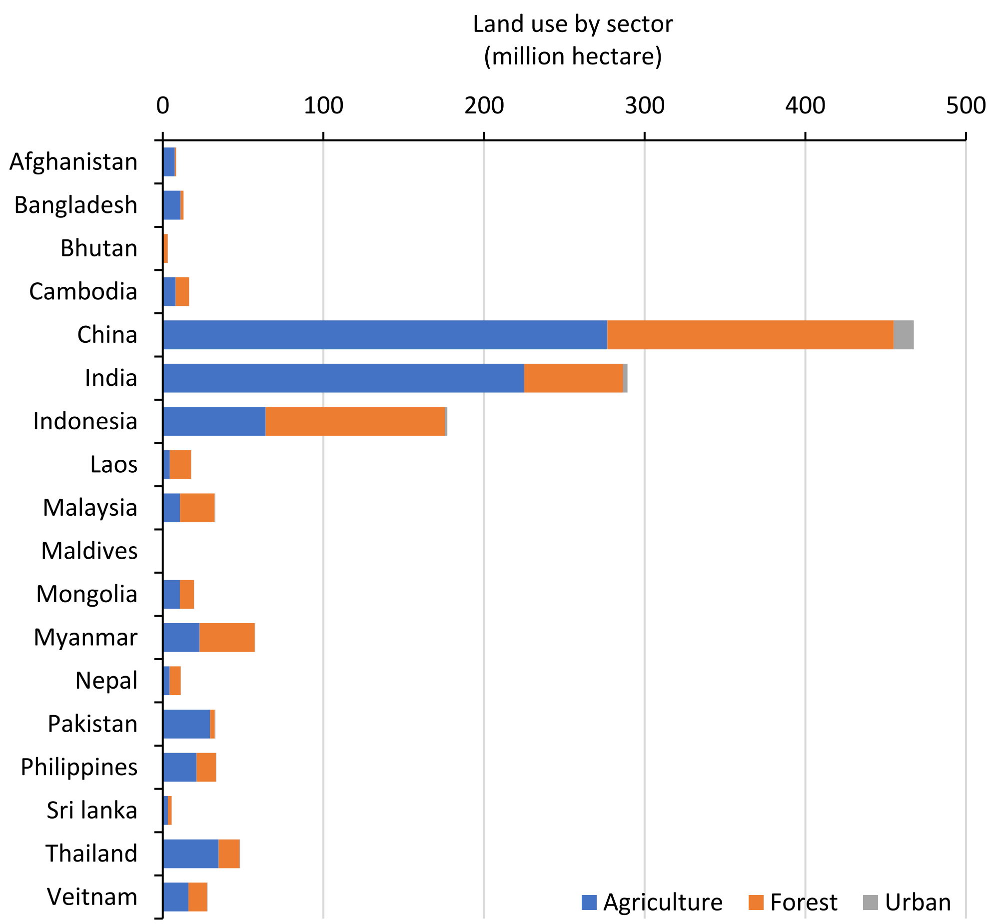


Figure 20 Land use, by sector in the Asia Pacific region (2015)

Land productivity in Asia Pacific region

Land productivity is the measure of the nation's total GDP ($) divided by total land area of a country. The Maldives is using land use as a resource the most efficiently in terms of monetary value. Maldives has generated more than one hundred thousand USD per hectare of its total land in 2015. However, Maldives is an exceptional case among all, its land area is 300 km^2 but its GDP was more than four billion dollar, and its economy depends mainly upon beach tourism that does not need massive land use. That is why its land productivity overshadows other nations. That is why Maldives is represented by dotted bars in main **Figure 21**, and Maldives land productivity is shown is originally shown on left side of **Figure 23** with different scale have the same unit. The second highest is Bangladesh, then followed by China, and Sri Lanka. Despite the large population of Bangladesh and China, massive economic growth in the recent time may be the reason for its high land productivity. On the other hand, Mongolia is the least efficient country followed by the Afghanistan, and Bhutan in terms of USD per hectare. Mongolia has generated only 75 USD per hectare in 2015. The reason behind the least efficient use of land by Mongolia may be due to the very low population, large land area, and low economic activities. This may also be the case for Afghanistan and Bhutan. Land productivity ($/ha) of each country under consideration in the Asia Pacific region are shown in **Figure 21**, for the year 1992, 2005, and 2015. Overall, all the nations of the Asia Pacific are showing the increase in land intensity that is showing the nation's efforts towards land efficiency.

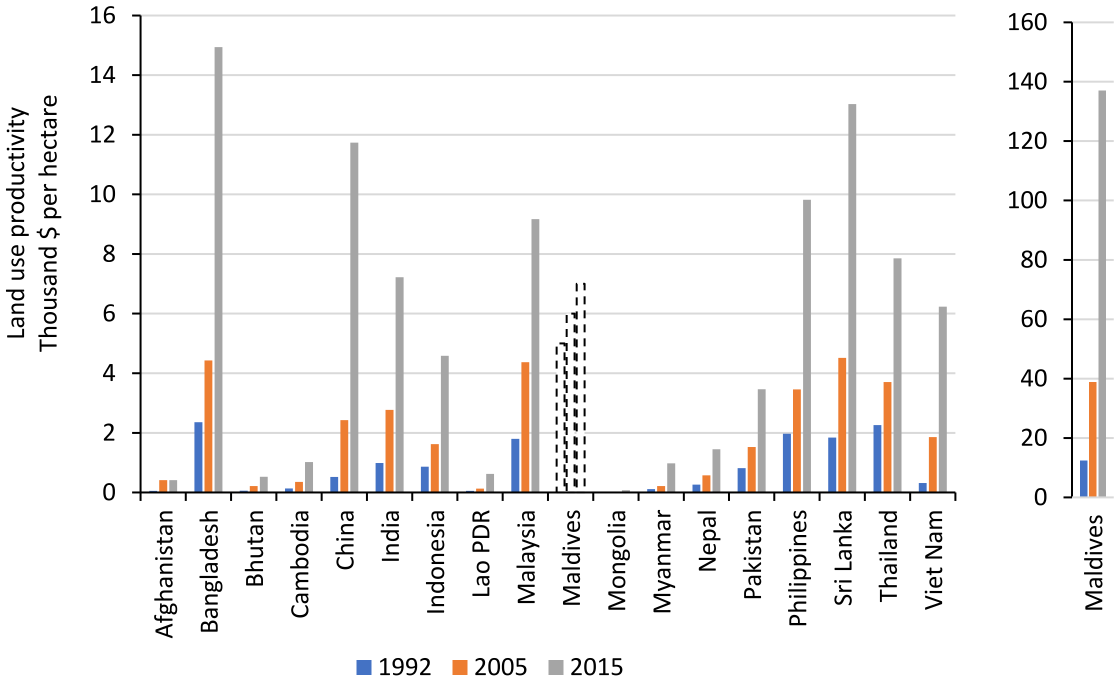


Figure 21 Land use intensity Asia Pacific region (1992, 2005, and 2015)

Land productivity of the Asia Pacific region is the measure of the ratio of overall GDP ($) to the total land-use area of the Asia Pacific region taken from World Bank. From 1992 to 2005, the land productivity of the Asia Pacific region has increased almost 12 times. Land productivity of the Asia Pacific region was 654 and 7922 $/ha in 1992 and 2015, respectively. Exponential growth of China, India, Indonesia, and Bangladesh are can be the main reason in the improvement land productivity of the Asia Pacific region. The trend of Land productivity in the Asia Pacific region from 1992 to 2015 is shown in **Figure 22**. The reason behind the massive improvement in the land use intensity may be due to the shift from agricultural to industrial economies.

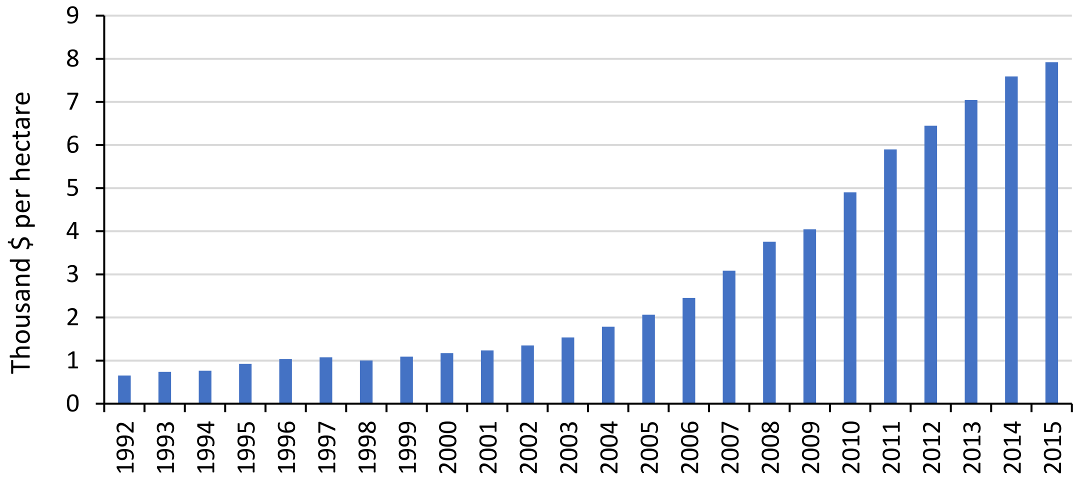


Figure 22 Land productivity for Asia Pacific (1992 – 2015)

Land use by major sector (Agriculture)

The land occupied by the agriculture sector increased by twelve million hectares in twenty-four years (1992 – 2014). China, India, Indonesia, are the top three countries contributing more the three-quarters of the total agricultural land use in the Asia Pacific region. The seven countries with the highest land use by major sector (Agriculture) in the Asia Pacific region in 2017, are shown in **Figure 23**. These top seven countries are contributing the most to agricultural land use, have fertile lands, are rich in water resources, and have a large labor force. In terms of percentage (%), the highest increase was noticed in Indonesia and followed by Myanmar. Land use in the agriculture sector of Indonesia and Myanmar increased by 7% and 4% respectively from 1992 to 2015.

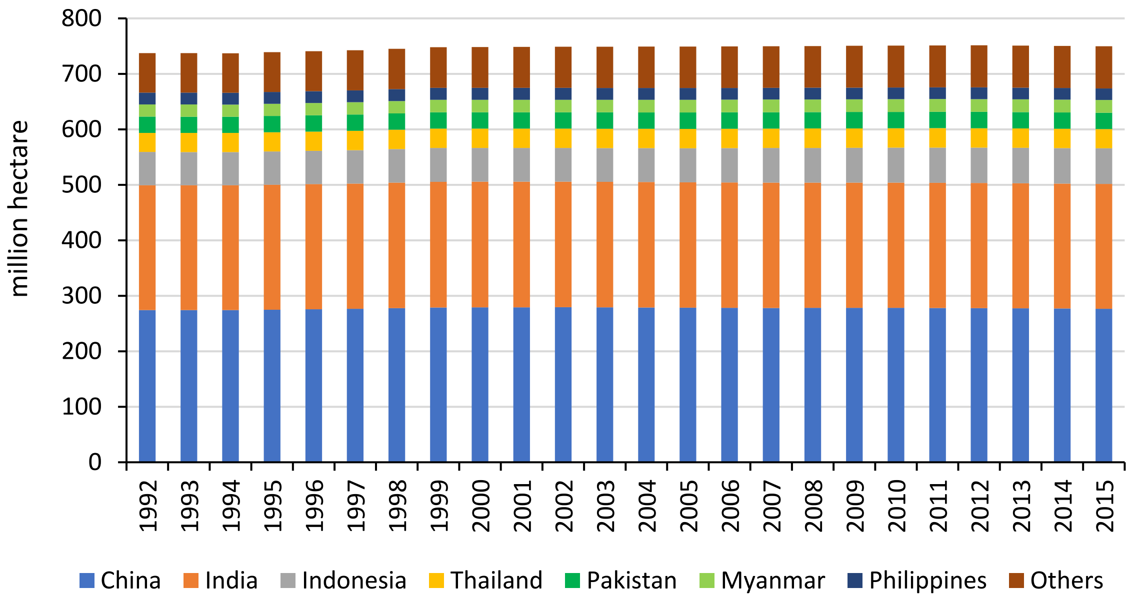


Figure 23 Land use by major sector (Agriculture)

3.1.5 Agricultural productivity

As said earlier in the conceptual framework, agricultural productivity has a prominent role to play in the economic and social agenda of developing countries. There has been a focus on increasing agricultural productivity in many regions such as Africa, Asia, and Europe to achieve agriculture-led growth and fulfil the targets on food and nutrition security. Thus, increased agricultural productivity is a key factor for achieving national goals of food security, rural poverty alleviation, as well as overall economic growth. For many countries within the Asia Pacific region, agriculture contributes significantly to both urban and rural livelihoods, trade income, and food security. Agricultural productivity represents the efficiency of the production process; it has been widely used as output per hectare (i.e., land productivity) and output per person (i.e., labour productivity). Land productivity in terms of cereal yield measured kg per hectare as shown in **Figure 24**.

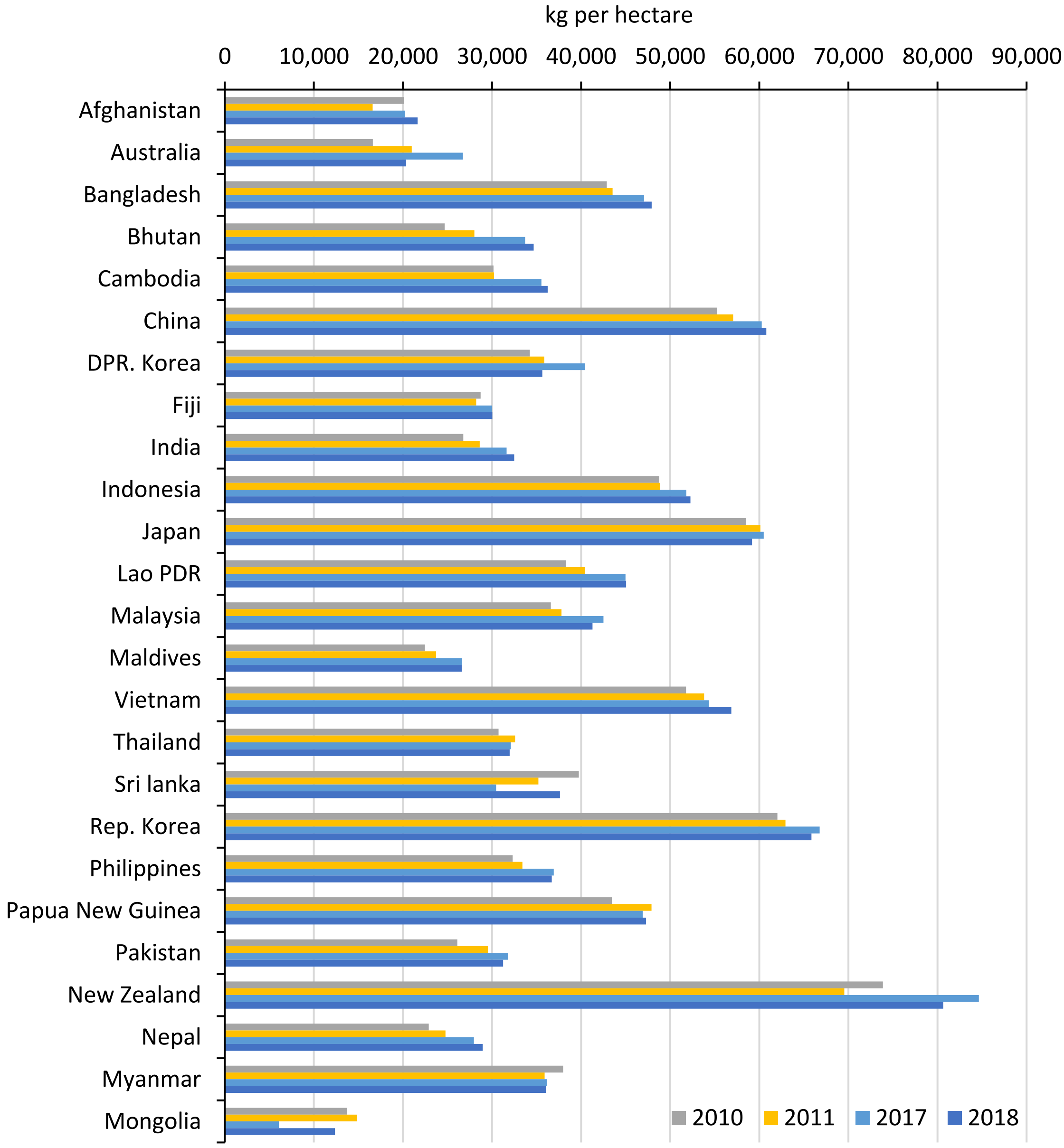


Figure 24 Cereal yield (land productivity) in The Asia Pacific (2010 – 2018)

Cereal crops harvested for hay or harvested green for food, feed, or silage and those used for grazing are excluded. In **Figure 25**, it is shown that cereal yield from 2010 – 2018, i.e., agricultural productivity has been on a continuous increase all over the region although with a bit of fluctuation and at different pace. New Zealand, amongst other countries, has the highest productivity. This overall commendable performance can be attributed to the wide spread of improved farming practices. Furthermore, another important way of measuring agricultural productivity is the value-added approach. This approach is essential for understanding profitability from factors of production (inputs) in agriculture, which is required for measuring the net production of production costs. Value-added is often used to compare the profitability of the agriculture industry with other industries. The agricultural productivity based on the agricultural value-added indicator has increased for more than third-quarter of the numbers of countries within the region, while others have a slight decline as shown in **Figure 26**.

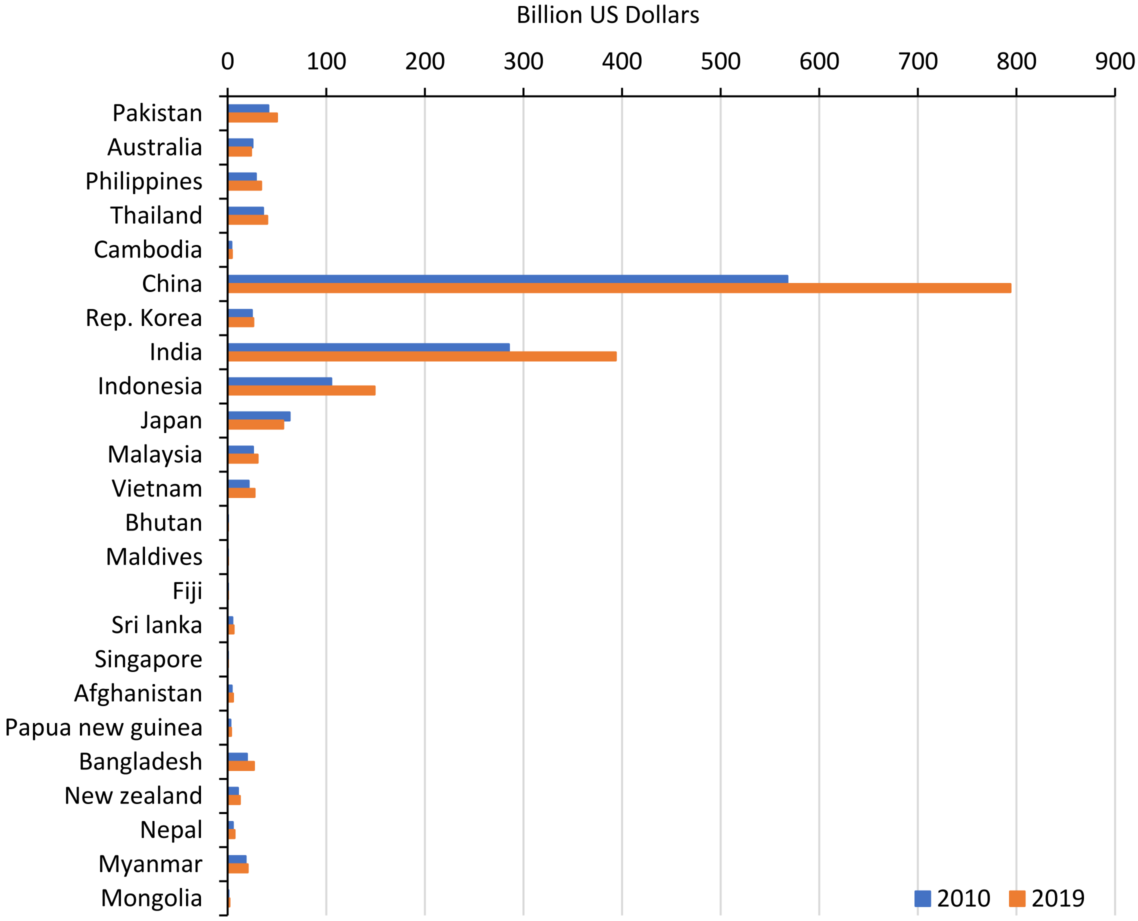


Figure 25 Comparison of agriculture value added per worker in The Asia Pacific between 2010 and 2019.

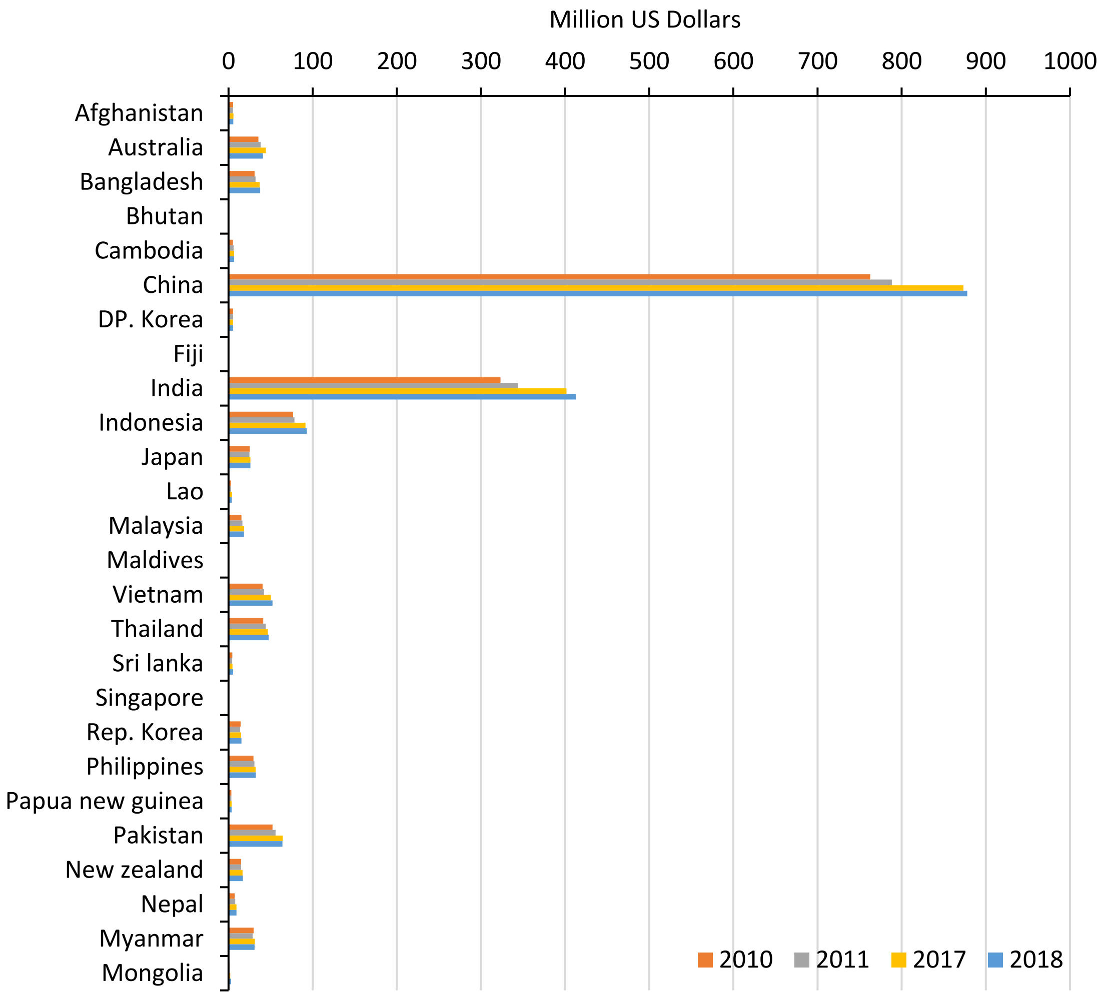


Figure 26 Value of agricultural product in The Asia Pacific (2010 – 2018)

3.1.6 Greenhouse gas emissions

The climate change has been identified as the release of GHGs associated with human activities, it is critical to develop a plan to measure and control these emissions (within sustainable limits). The Paris agreement, which includes both industrialized and developing countries with market economies and strives to cut GHG emissions on a global scale, bolstered these notions (UNFCCC, 2016). The total GHG emissions indicator, expressed in million metric tonnes of CO_2 equivalent, includes all GHG emissions excluding short-cycle biomass burning (such as agricultural waste burning and Savannah burning) but including other biomass burning (such as forest fires, post-burn decay, peat fires, and drained peatland decay), all anthropogenic CH_4 emissions, N_2O emissions, F-gases (HFCs, PFCs, and SF_6), and CO_2 emissions of drained peatlands.

Data from 2010 to 2017 were sourced from the Emissions Database for Global Atmospheric Research (EDGAR), release EDGAR v5.0 (1970 – 2017) in November 2019. This database encompassed total emissions of CH_4, N_2O, and F-gases and five aggregate sectors for CO_2 emissions. It is important to state that the scope of measuring the individual components that make up this indicator summed up all GHG emission types, and this include emissions from peat fires and decay. The raw data on emissions quantity (in tonnes) has been converted to the 100-year global warming potential (GWP) expressed in tonnes of CO_2-eq. According to the data derived and analysed, China was found to emit the highest quantity of GHGs within the Asia Pacific region and has increased the most annually in relative contribution: from 38% in 1970 to 57% in 2010, and then 58% in 2017. Emissions has constantly accelerated, and this is the major underlying trend for the whole region over 2000 to 2017 as shown in **Figure 27**. **Figure 28** below presents GHG resulting from agriculture for countries within the Asia Pacific region the significant contribution of agriculture - as it is responsible for 12% - to the overall GHG emissions while **Figure 29** shows how 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 the expansion of agriculture as research and innovations in the agriculture sector keeps growing within the region. Over the last 60 years and most particularly during the study period, China witnessed enormous economic growth and urbanization bringing to life huge amount energy use (fuel combustion). The emissions from fuel combustion accounted for 67% of the total GHG emissions between 2010 – 2017 for the Asia Pacific region. These emissions have steadily increased over the years prior to 2010 – 2017 across all countries within the region as shown in **Figure 27** and **Figure 28**. On the general note, with the information provided for the GHG total emissions indicator, China and India contributes 62%, 8% of the total GHG emission between 2010 – 2017 respectively as shown in **Figure 30**.

The other countries within this region have also grown in a similar fashion but not at the same rate as economic structure and industrialization influences, which are the most important drivers of emission, are not exactly the same in all countries. Other than China, countries like India, Indonesia, and Australia have significant - CO_2 emissions from industry, emissions from agriculture, and the energy sector while Cambodia, Japan, and Lao PDR have experienced fluctuating emissions from agriculture emissions as shown in **Figure 28**.

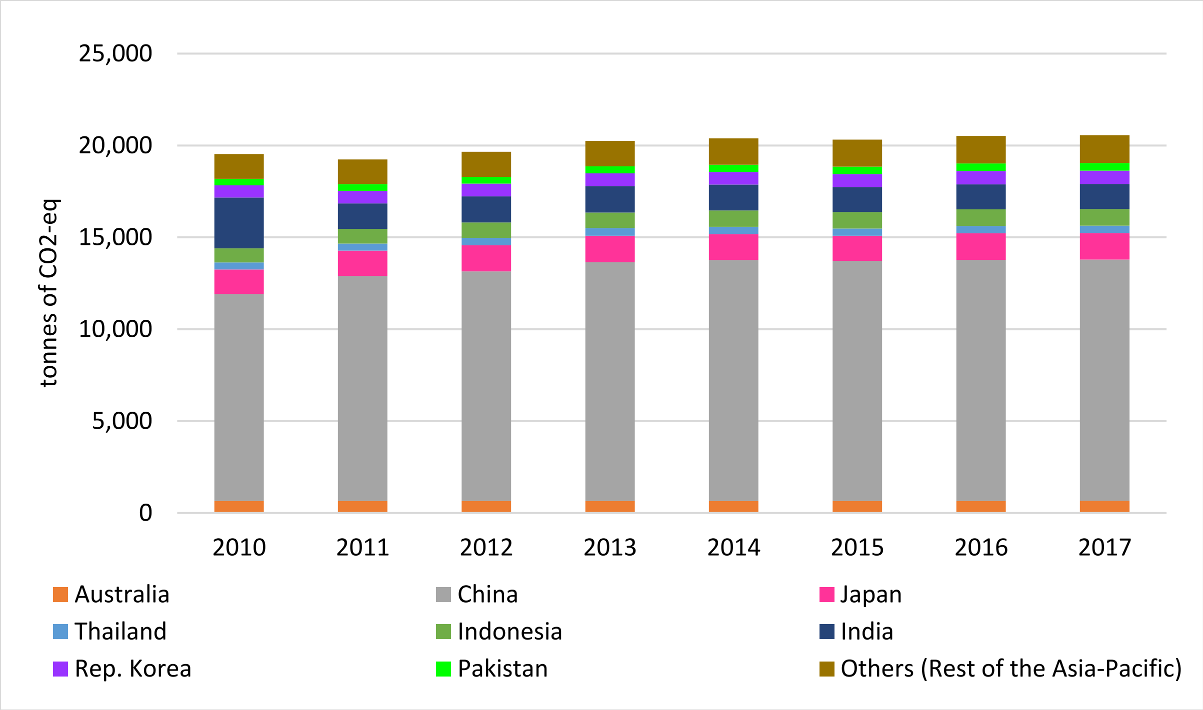


Figure 27 Total GHG emissions for the Asia Pacific region (2010 – 2017) (FAOSTAT, 2017)

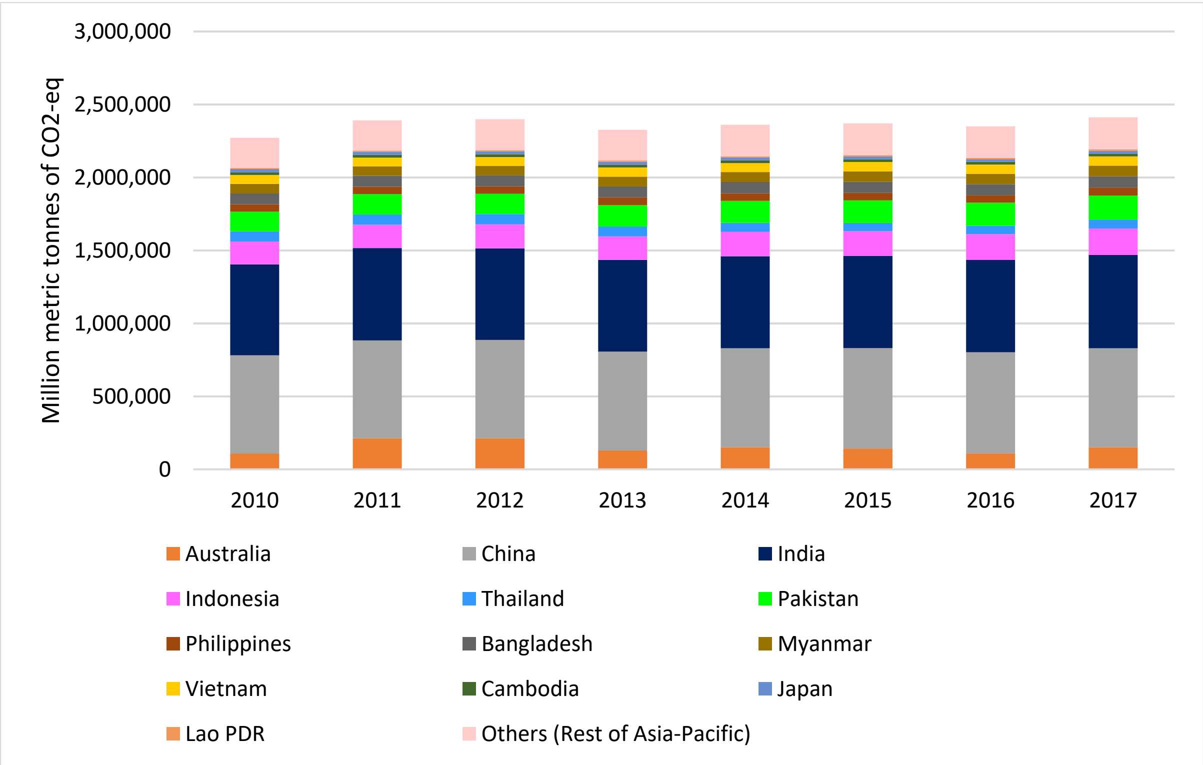


Figure 28 GHG emissions resulting from agriculture for the Asia Pacific region (2010 – 2017).

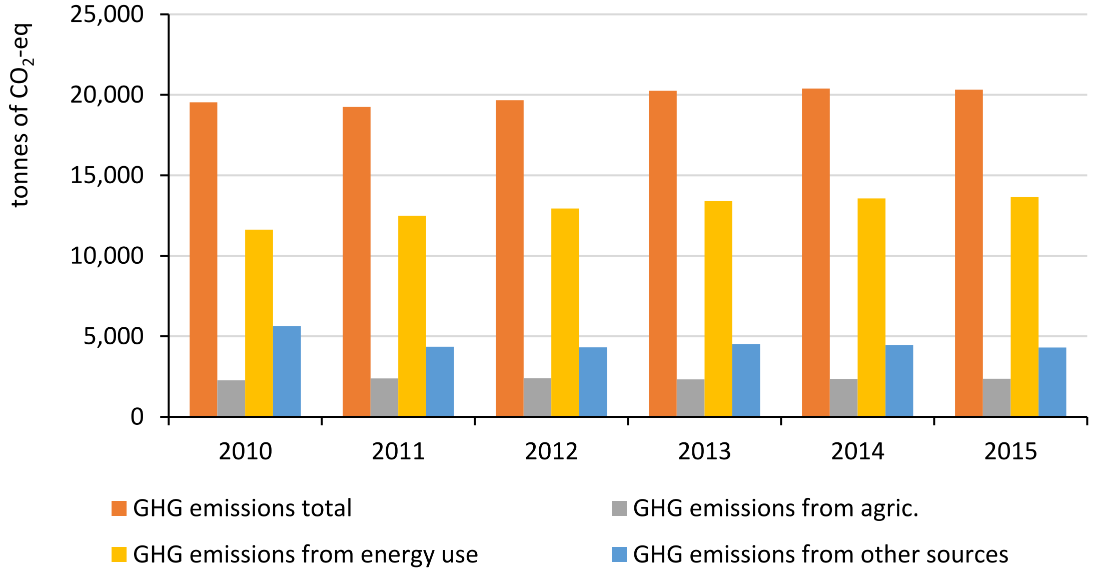


Figure 29 Comparison between GHG from energy use, GHG from other sources as well as GHG total in the Asia Pacific (2010 – 2015).

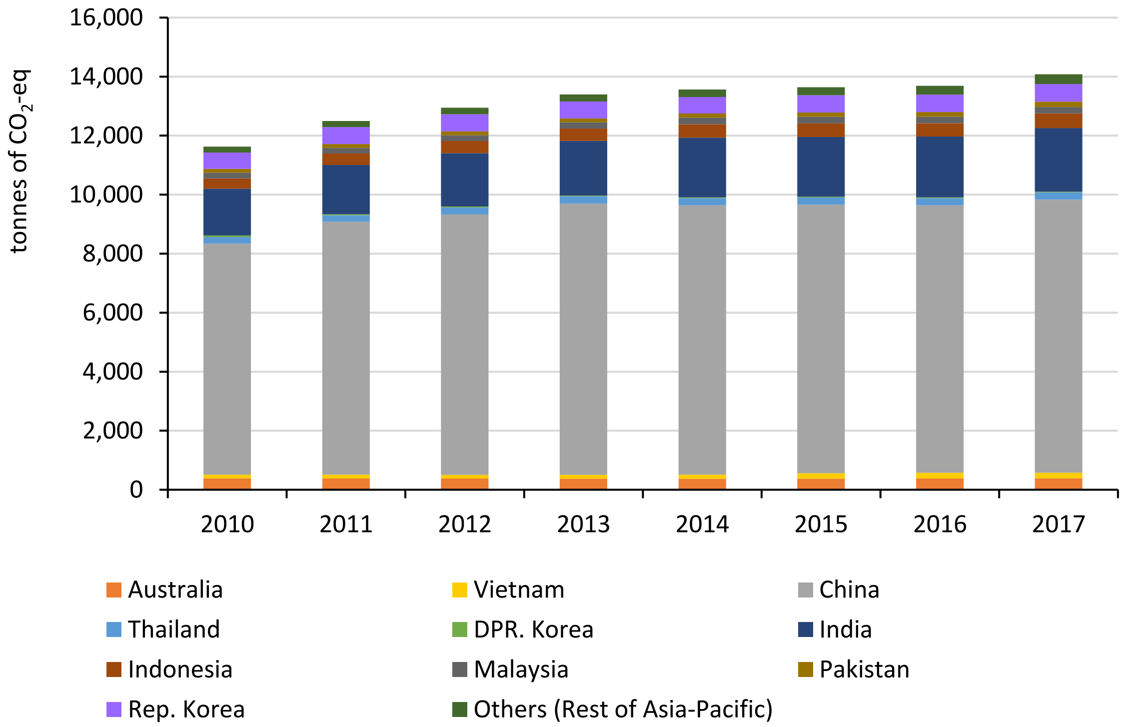


Figure 30 CO_2 emissions from fuel combustion for the Asia Pacific (2010 – 2017).

3.1.7 Waste management

Firstly, it is imperative to state the kinds of waste materials generated in societies. These wastes are of several types which include municipal (household, commercial, and demolition waste), biomedical, and electronic (e-waste) waste. The enormous waste being generated nowadays can be attributed to the continual increase in population and urbanization; this increment has been at an unprecedented rate. Also, technological innovations in the electronic industry are usually very fast, resulting in rapid redundancy and a decreasing lifetime of products. In 2016, an estimated 1.2 billion tonnes of municipal solid garbage was produced in Asia; this figure is expected to rise to 1.5 billion tonnes by 2030 and 1.9 billion tonnes by 2050 (World Bank, 2018). All these culminate in causing waste management problems. To solve these problems, effective waste management schemes need to be implemented. Waste management schemes should include the collection and proper disposal of this waste. Efficient and effective solid waste management schemes are critical for achieving sustainable development as well as sustainable consumption and production in various countries. The waste management analysis within the Asia Pacific region is faced with severe data limitations. With the exception of countries such as China and Fiji, collection amounts are low as shown in **Figure 31** and many have no data, the collection coverage (percentage) by cities within the region is shown in **Figure 32**, while only 44% and 71% collection rates are reported in the entire South Asia and East Asia (Kaza et al., 2018). As a result of the poor waste collection, open dumping (unsanitary landfilling) of waste prevails as the most practiced waste management approach in these low-income countries within the region. The effective waste management approach is being practiced in some countries within the region as they have moved from waste collection to recycling and incinerating these wastes as shown in **Figure 31** and **Figure 33** – **Figure 35**.

Waste management in the other countries has been hampered due to problems that might be related to technology, infrastructure, policy etc. For instance, Solar panels are also becoming increasingly popular in the energy sector, particularly in China and ASEAN region. It does not use many rare metals, but it exports a considerable volume of solid waste without efficient end-of-life treatment. A significant number of countries within this region have already established national policies to address the challenges associated with waste management largely through the sustainable development as well as environmental act regulatory frameworks. Countries like Indonesia, Indian, Malaysia, the Philippines, and Thailand have specific Acts/laws on waste management. Whilst putting regulatory laws in place, equal importance should also be given to solutions and campaigns for waste reduction/prevention through sustainable consumption and production as some countries within the region have embraced.

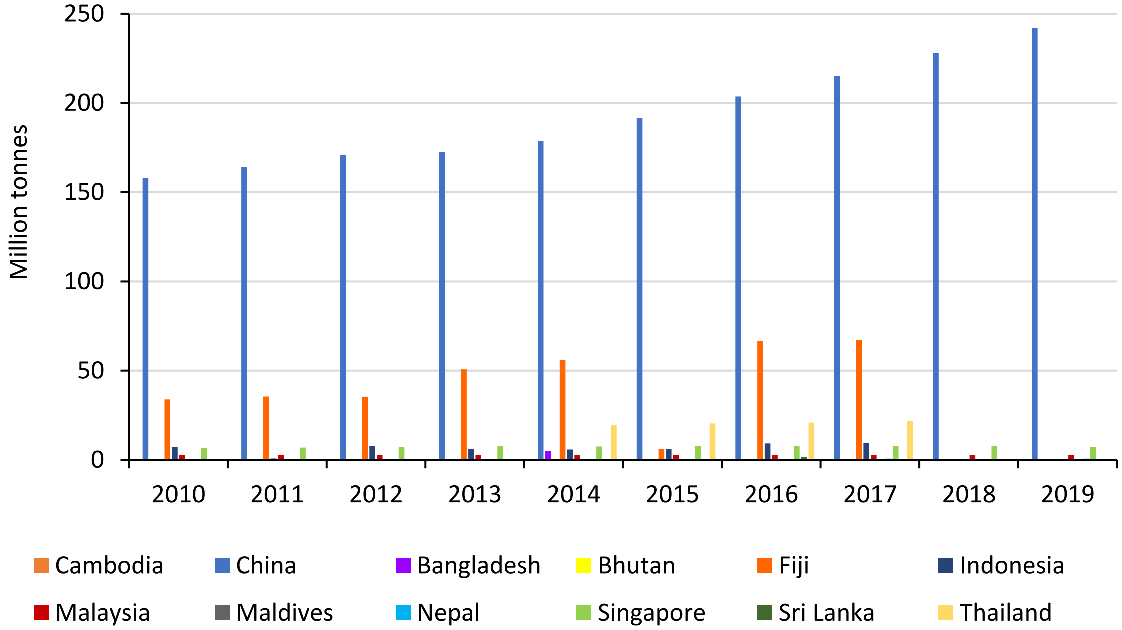


Figure 31 Municipal waste collected in Asia Pacific countries (2010 – 2019)

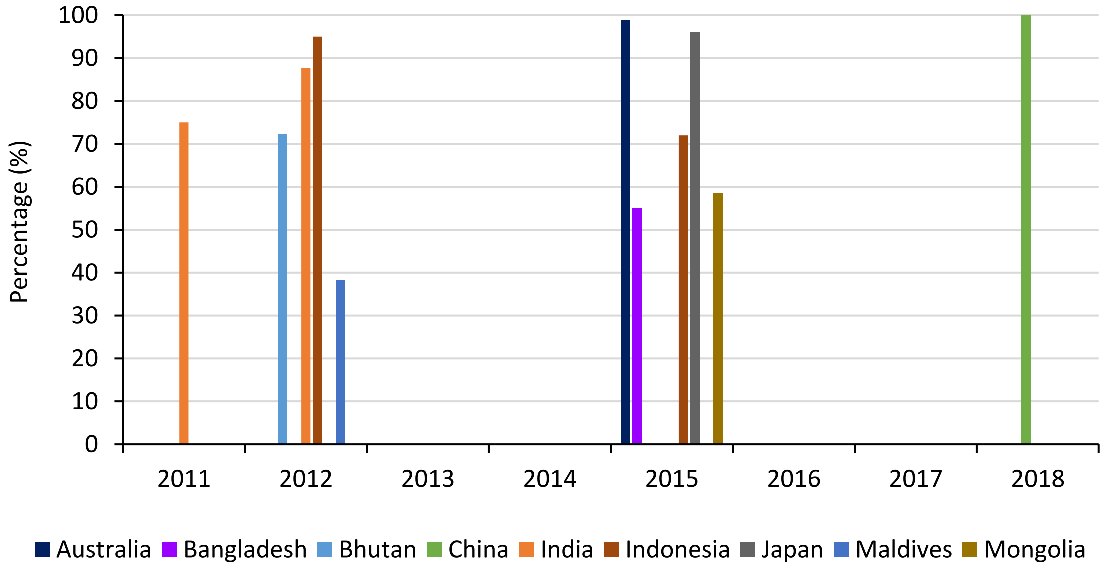


Figure 32 Municipal waste collection coverage in cities within the Asia Pacific region (2011 – 2018).

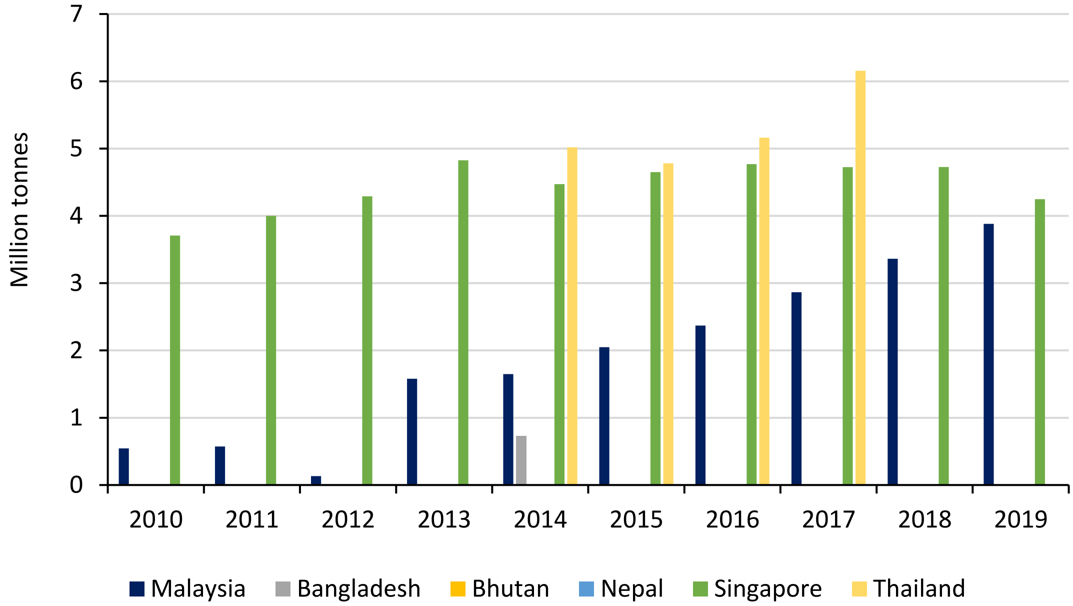


Figure 33 Municipal waste recycled by Asia Pacific countries (2010 – 2019)

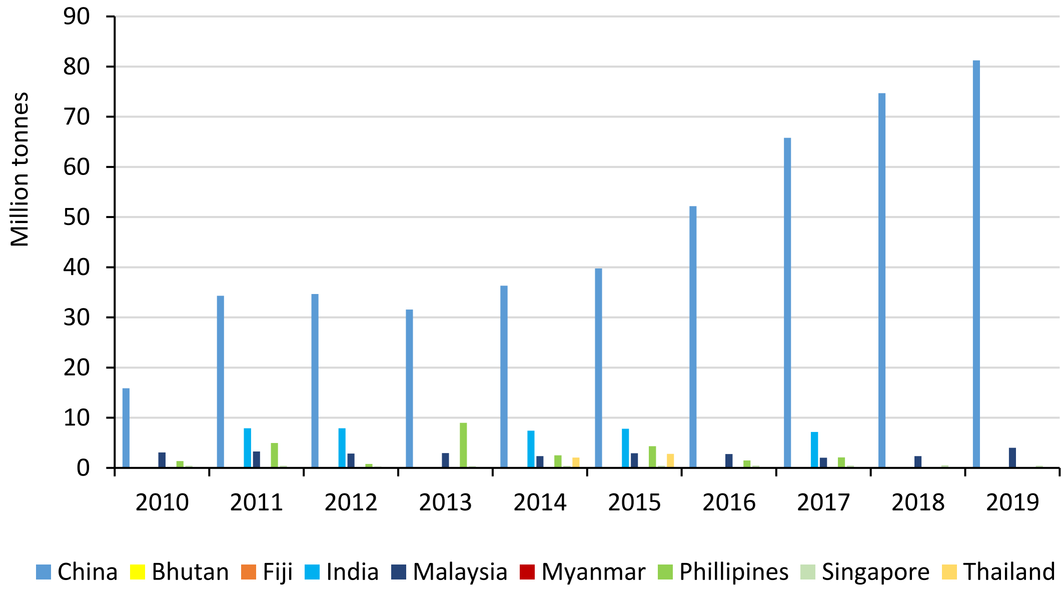


Figure 34 Hazardous waste generated by Asia Pacific countries (2010 – 2019)

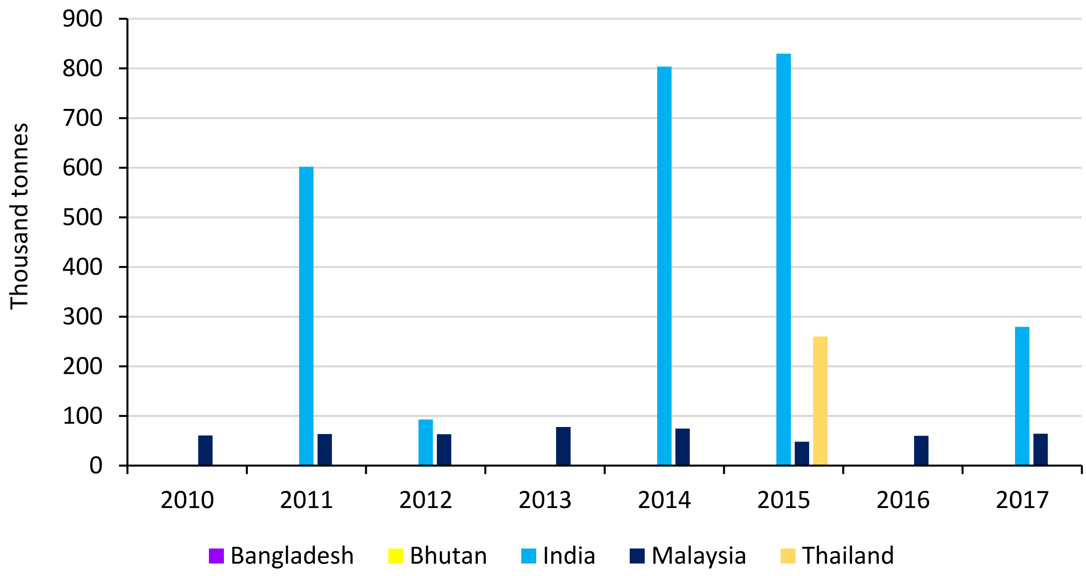


Figure 35 Hazardous waste incinerated by Asia Pacific countries (2010 – 2017)

3.2 Resource efficiency

3.2.1 Material intensity of the economy

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. The Asia Pacific developing countries are continuing to industrialize which causes the demand of primary materials to further escalate in these countries. The efficient use of materials can aid these to attain a more competitive and environmentally sustainable development route. In this report, the material intensity indicator is defined as the domestic material consumption per unit of gross domestic product (DMC per GDP). 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.

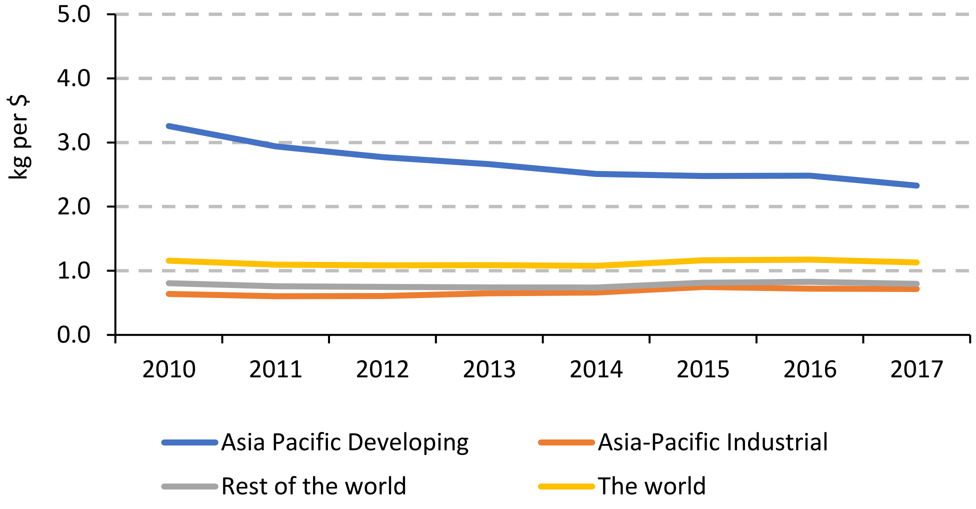


Figure 36 Material intensity for the Asia Pacific, and World groupings (2010 – 2017)

Figure 36 exhibits the comparison of material intensity (kg per $) between the Asia Pacific developing, the Asia Pacific industrial, the rest of the world, and the whole world. The material intensity of the Asia Pacific industrialized, rest of the world, and the entire world remained almost constant during the covered time series. On the other hand, there was a tremendous improvement in the material intensity of the Asia Pacific developing region with the amount of material to produce one US$ in terms of GDP has decreasing by around 30% from 2010 to 2017. In spite of this huge improvement, the material intensity of the Asia pacific developing region is still 7.7 times higher than the Asia Pacific industrialized, 3.9 times higher than the rest of the world, and 2.4 times higher than the whole world. This passiveness of the Asia Pacific developing region in terms of material intensity is due to 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 economic structure.

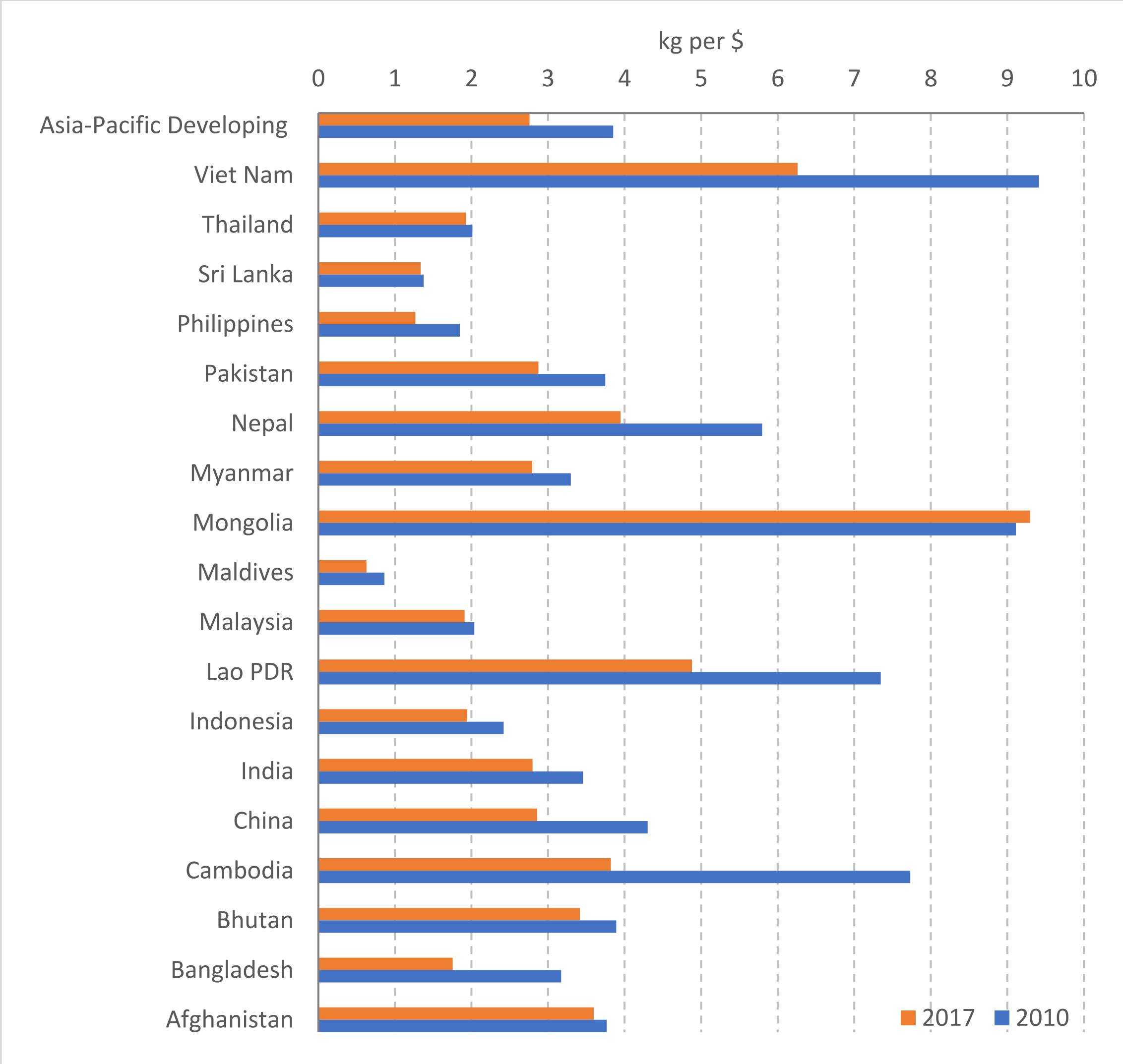


Figure 37 Material intensity for the Asia Pacific developing countries (2010, 2017)

Figure 37 shows the material intensity of various Asia Pacific developing countries. It can be seen that all countries in the region have improved their material intensity, especially, Cambodia, Vietnam, Lao PDR, Bangladesh and Nepal have remarkably decreased their material intensity except Mongolia whose material intensity has slightly increased in 2017 as compared to 2010. The regional material intensity has also improved in 2017 as compared to 2010 which is largely reflected in the individual country level statistics. If all the Asia Pacific developing countries keep on following this pattern the region can achieve decoupling, that is much needed indeed.

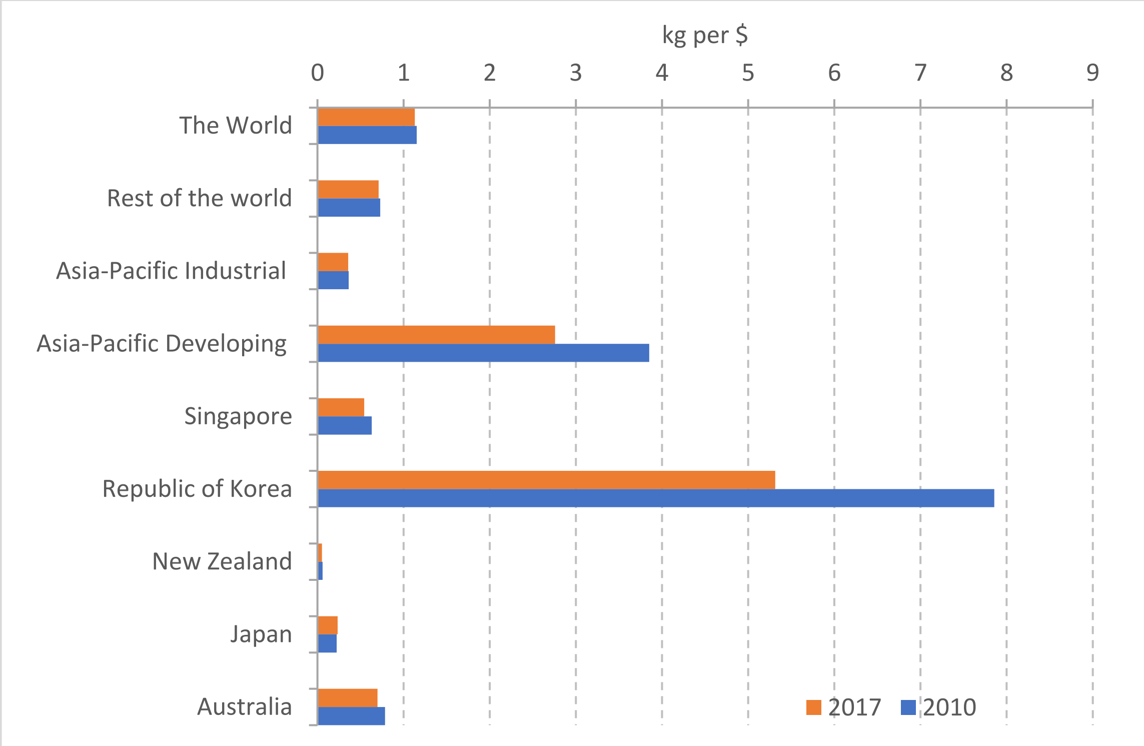


Figure 38 Material intensity for the Asia Pacific industrialized countries (2010, 2017)

The material intensity of the Asia pacific industrialized countries, as well as regional material intensities, are presented in **Figure 38**. It can be seen that all the Asia Pacific industrialized countries have improved their material intensity in 2017 as compared to 2010, except Japan. New Zealand has attained the lowest material intensity at 0.06 kg/$ in 2010 to 0.05 kg/$ in 2017, while the Republic of Korea has performed tremendously well by decreasing its material intensity from 7.86 kg/$ in 2010 to 5.31 kg/$ in 2017. The material intensity of Japan has slightly increased in 2017 (0.23 kg/$) as compared to 2010 (0.22 kg/$). Despite different trajectories of material intensity in the Asia Pacific industrialized economies, the overall regional material intensity remained unchanged. The material intensity of the Asia Pacific industrialized region was one-third that of the entire world, and half of the rest of the world.

3.2.2 Energy intensity of the economy

The overall energy intensity of an economy refers to the quantity of energy consumed for generating products and services in tonnes of oil equivalent (toe) evaluated in terms of GDP (in thousand 2015 USD), which is related to energy efficiency. The energy economy of the region is continuously improving (as can be seen in **Figure 53** and **Figure 54**). Using energy more efficiently lowers costs and is critical to reaching a low-carbon development path. The employment of energy-efficient technology in the building, transportation, heavy industrial, and manufacturing sectors is expected to increase energy consumption in the Asia Pacific area during the next few decades. On the other hand, in this report, the data for energy intensity is presented just until 2018, however, a recent data for 2019 and 2020, which may exhibit different trends due to the pandemic, is missing. Furthermore, the data for some countries such as Afghanistan, Bhutan, and Maldives is also missing.

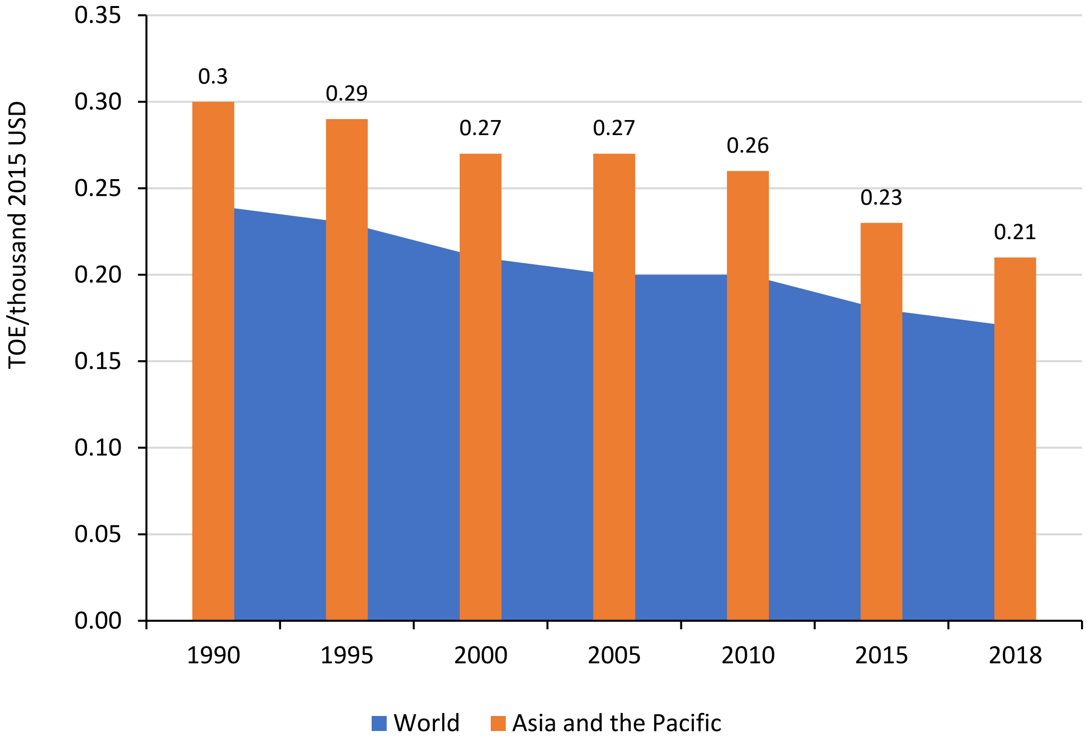


Figure 39 Energy intensity of Asia Pacific and World (1990 – 2018)

Figure 39 shows that the energy intensity of the Asia Pacific region is higher than that of the world; however, it is rapidly improving. In this region, energy intensity has steadily decreased from 0.3 in 1990 to 0.21 toe/thousand 2015 USD in 2018. The analysis of some developing nations in the Asia Pacific region is limited by the data availability (see **Figure 40**). However, almost all the countries are showing a similar trend of energy intensity reduction. Some potential factors that may influence the outcomes are export prices, currency rates, and the international price of fuels.

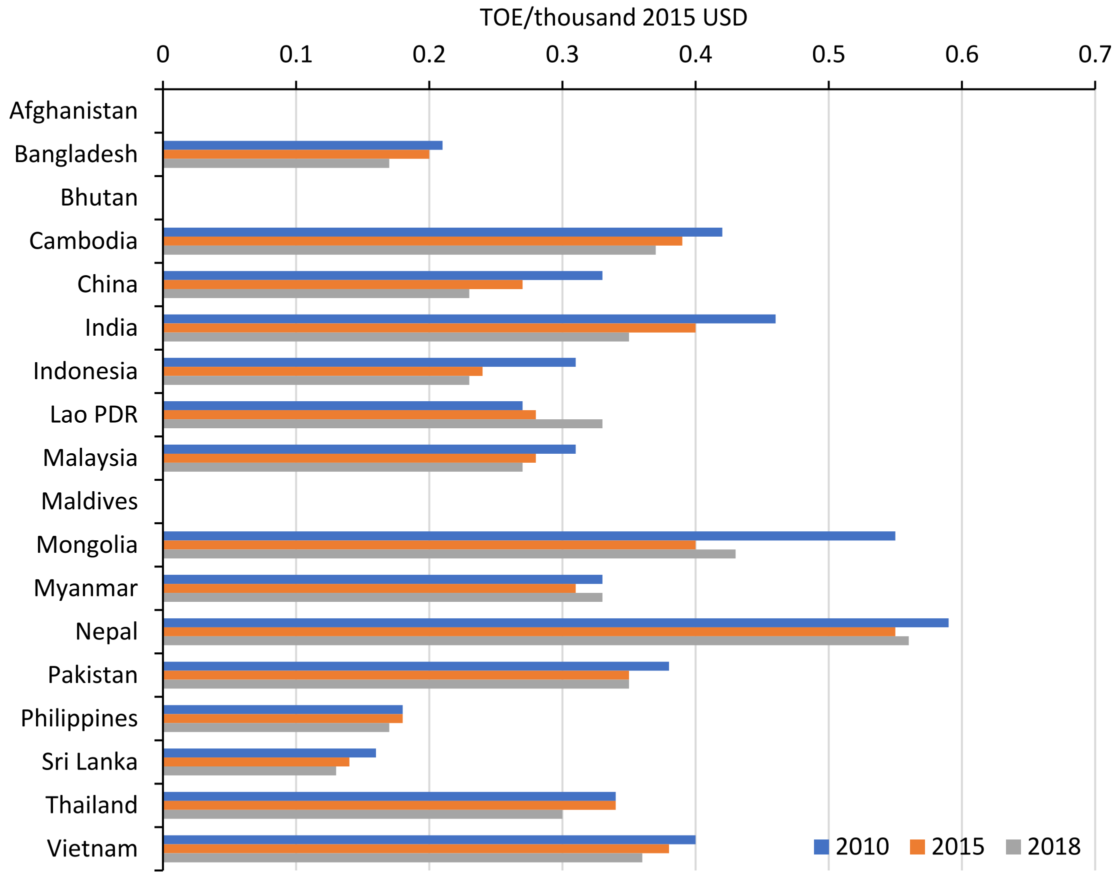


Figure 40 Energy intensity for Asia Pacific developing countries (2010, 2015, 2018)

3.2.3 Water intensity of the economy

It is the measure of the use of water (liter) to earn a dollar. All the nations under study have improved their water use efficiency as shown in **Figure 41**. Eight out of 18 countries have improved more than 40 % in seven years (2010 to 2017). The highest improvement was for Bangladesh at 35 %. In absolute terms, Maldives is using the least water to add a dollar to the economy. Afghanistan's water use for a dollar is the highest among all the nations under study. It may be due to the outdated, less efficient irrigation infrastructure in Afghanistan. On the other hand, the reason behind the most efficient water use by the Maldives is, maybe very low water uses for agriculture that is the least water-efficient sector in terms of monetary values.

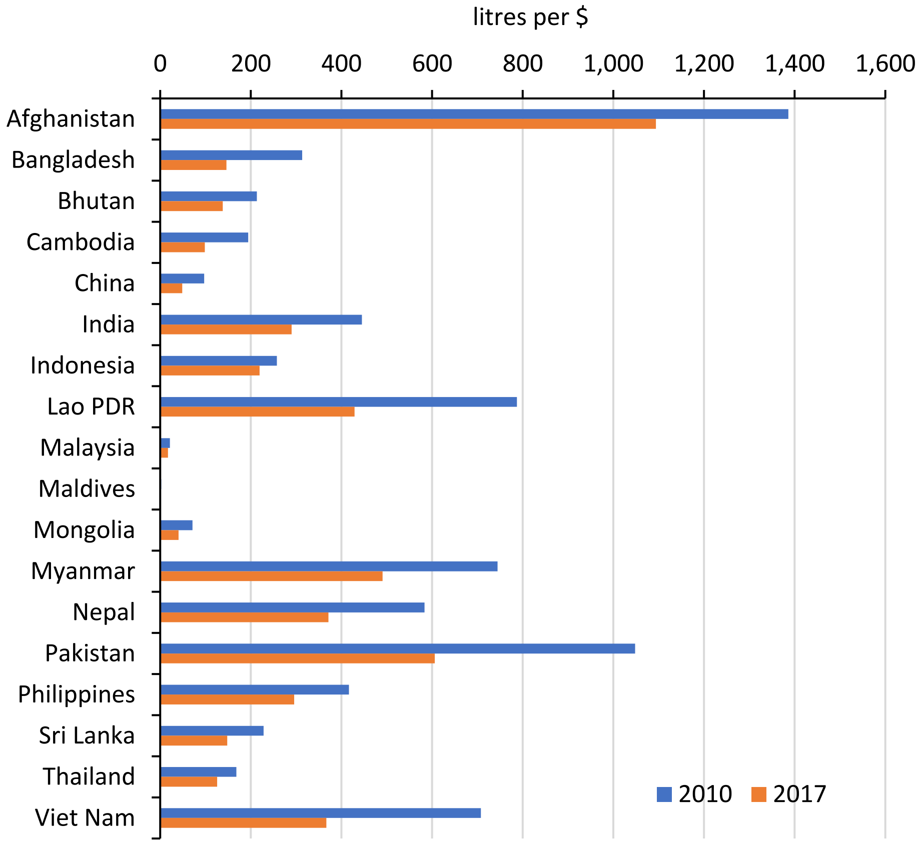


Figure 41 Water intensity of the economy in Asia Pacific region (2010, 2017)

3.2.4 GHG intensity of the economy

GHG emission intensity can be defined as the amount of GHG emissions per gross domestic product. This indicator represents the GHG intensity of the production processes (energy-related emissions) i.e., the GHG emission intensity associated with the production of input materials and logistics of a product. This can be done for the economy as a whole or for specific industries. The GHG intensity is usually measured in metric tonnes per GDP. Countries such as China and Mongolia had the highest emission intensities this is a result of the use of high GHG emission energy source. While China's industrial capacity expands, China is a party to the Paris Agreement to stop its emissions from rising by 2030. China's program outlines increasing the role of natural gas in primary energy consumption because natural gas emits fewer GHGs per unit of energy produced than coal, which is another significant source of energy in the country. This measure starting to yield dividend as China and Mongolia's GHG intensity has decreased minimally by an average of 3% and 1.8% respectively over the study period (2010 – 2018). **Figure 42** shows an insignificant decrease – as little as an average of

0.46% over the 3-year period - trend for some of the countries while this indicator shows a steady state of emission intensity for other countries for the years 2010 – 2012.

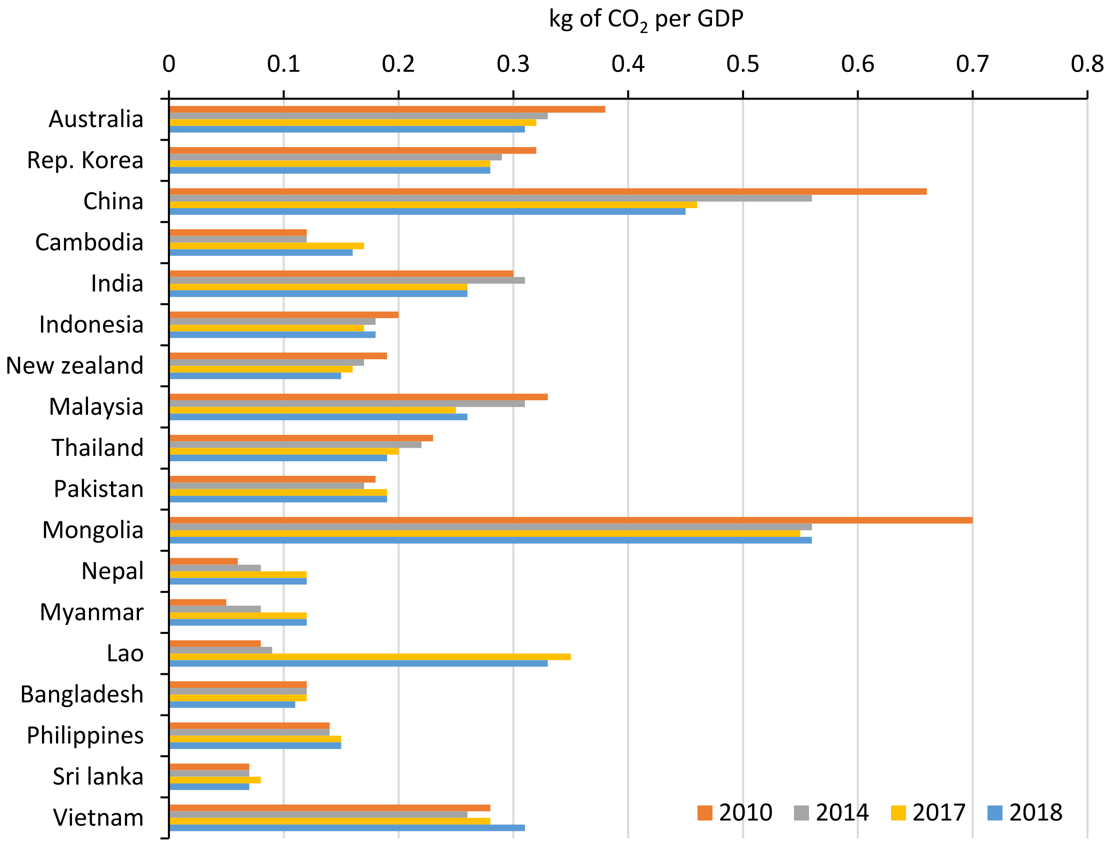


Figure 42 GHG intensity (kg per GDP) for Asia Pacific (2010 – 2018)

3.3 Consumption-based indicators for natural resource use

3.3.1 Material footprint

When economies develop, they import final goods to replace a large portion of the domestic production of final goods, and the extractive activities on which they rely. The upstream primary material requirements for those commodities, as well as the associated environmental impact, remain in the country of production. This is how developed economies outsource their material-intensive activities to developing countries. This process has enabled wealthier economies to minimize their dependence on resource extraction. The material footprint of consumption features the global material extraction to ultimate demand, which includes household consumption, government consumption, and capital investment. The indicator provides information about the actual primary material demand of any economy without including the extraterritorial trade intervention. Furthermore, the indicator reports the real quantity of primary resources consumed and capital investment on which a country relies, regardless of where the material extraction happened in the global economy. The material footprint of consumption has swiftly increased in Asia Pacific. China is the most prominent country in this region with an annual average growth of around 9%. This rapid growth in material footprint also reflects the immense growth of GDP in China. Other than China, a rapid growth in material footprint was observed in India, Vietnam, the Lao PDR, and Singapore. The growth in material footprint in the Asia Pacific region is presented in this section. The data for the material footprint is sourced from the UN environment website (UNEP, 2021). The time series here covers the period 2010 to 2017.

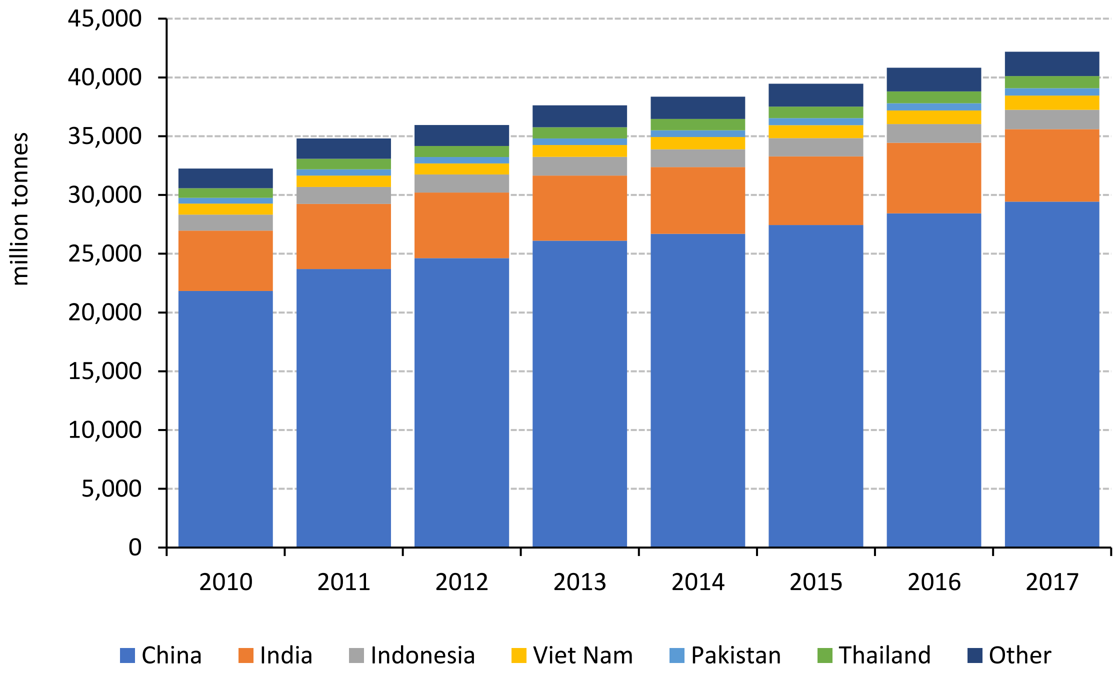


Figure 43 Material footprint, the Asia Pacific developing countries (2010 – 2017)

Figure 43 shows the material footprint of consumption of the Asia Pacific developing countries. It can be seen from that the material footprint of consumption has continuously increased in the Asia Pacific developing countries. China is at the top of the list with a total material footprint of consumption of 29.4 billion tonnes in 2017 up from 21.8 billion tonnes in 2010. This rapid growth in China's material footprint of consumption also reflects the immense growth of GDP in China. After China, five countries including India, Indonesia, Vietnam, Thailand, and Pakistan are the Asia Pacific developing countries with a high material footprint of consumption in 2017 at 6. 16, 1. 65, 1. 21, 1. 03 and 0. 63 billion tonnes, respectively.

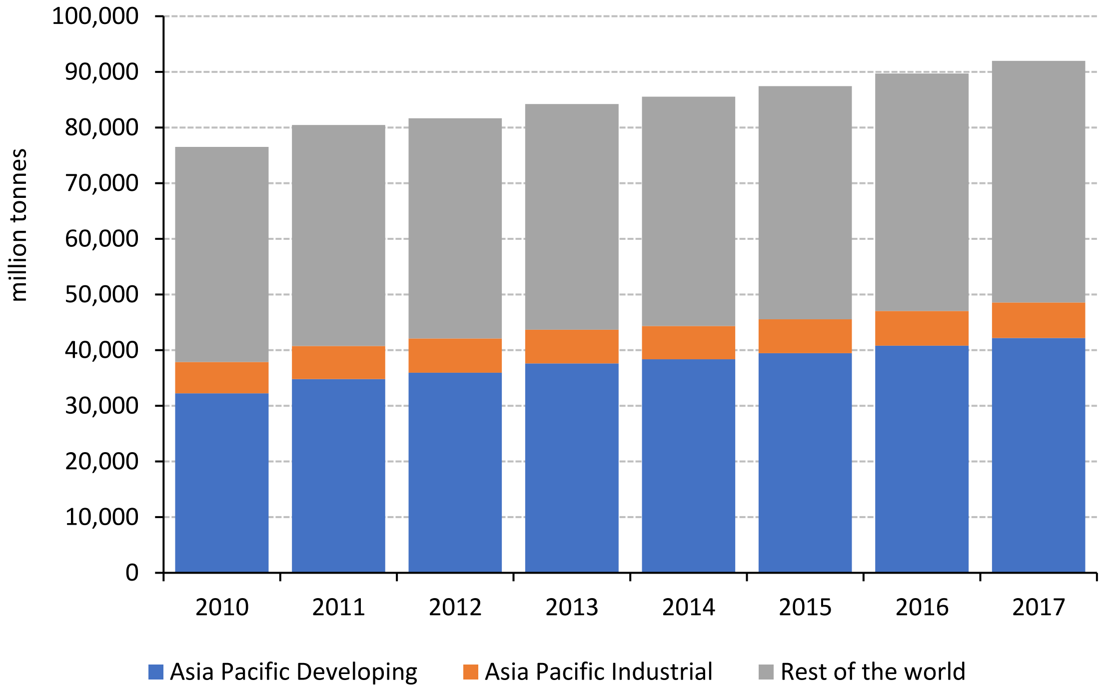


Figure 44 Material footprint, the Asia Pacific region, and the rest of the world (2010 – 2017)

Figure 44 compares the annual material footprint of consumption at the regional level for the Asia Pacific developing, the Asia Pacific industrialized, and the rest of the world from 2010 to 2017. The average annual material footprint of consumption of the Asia Pacific developing region has increased at a compound rate of 3.42% per annum, while for the Asia Pacific industrialized and the rest of the World it grew at a rate of 1.52% per annum, and 1.47% per annum, respectively. The higher growth rate of material footprint of consumption in the Asia Pacific developing region as compared to the Asia Pacific industrialized and the rest of the world was due to the increasing material standards of living in leading Asia Pacific developing economies. Especially China whose material footprint of consumption was even higher than the Asia Pacific industrialized countries combined.

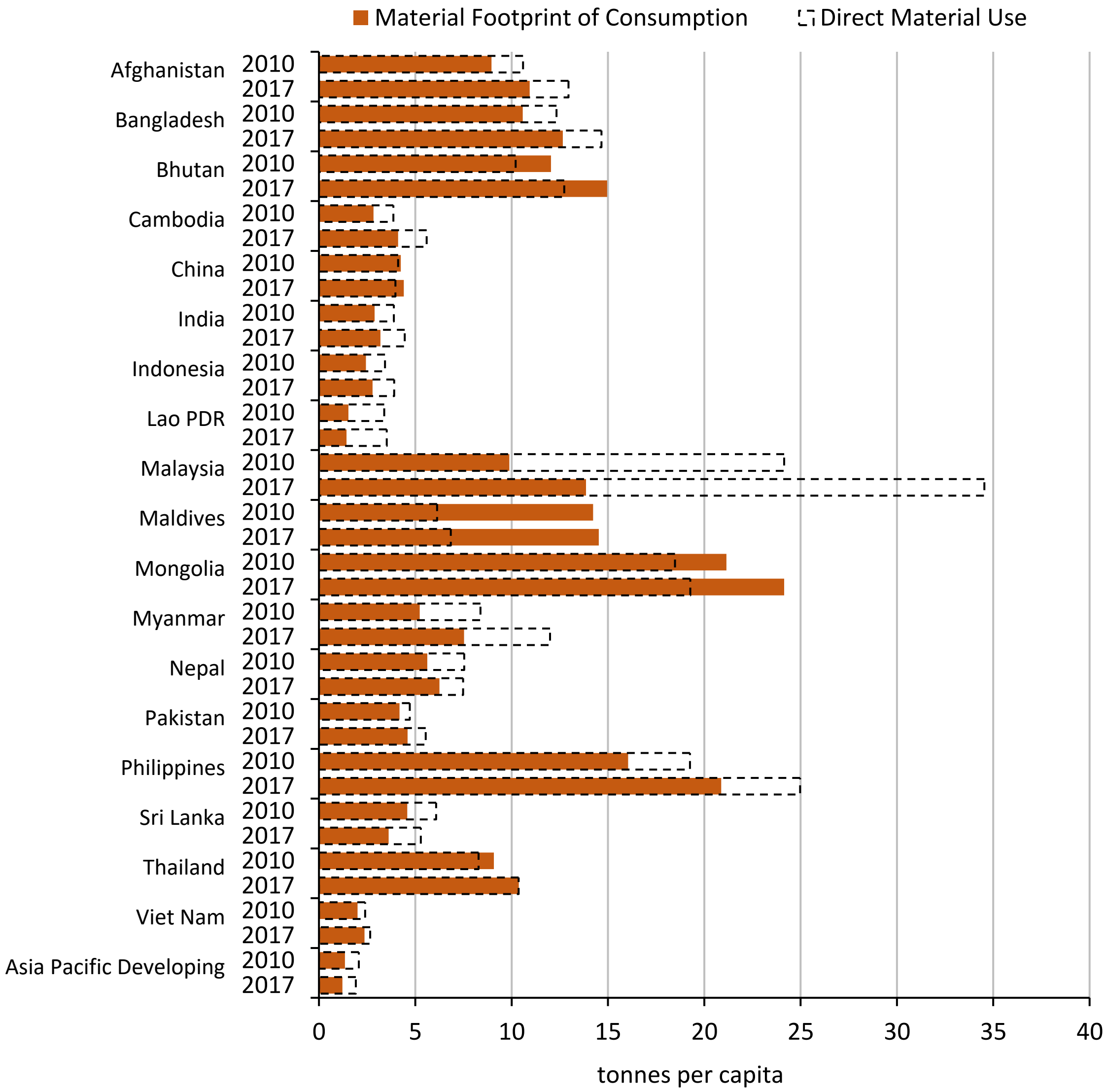


Figure 45 Material footprint per capita compared to domestic material consumption per capita, the Asia Pacific developing countries (2010, 2017)

Figure 45 compares the material footprint per capita and the DMC per capita of the Asia Pacific developing countries for 2010 and 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 48** that 14 out of the 18 Asia Pacific developing countries have higher DMC per capita than material footprint per capita. Only Maldives, Malaysia, Thailand, and Bhutan have a higher material footprint per capita than DMC per capita. This shows that most of the Asia Pacific developing countries have attained a higher standard of living as their material use for production sector is higher that provide substantial opportunities of employment creation and income generation except for the later four countries. Overall, the DMC per capita of the Asia pacific region is higher as compared to the material footprint per capita as reflected by the country-wise statistics.

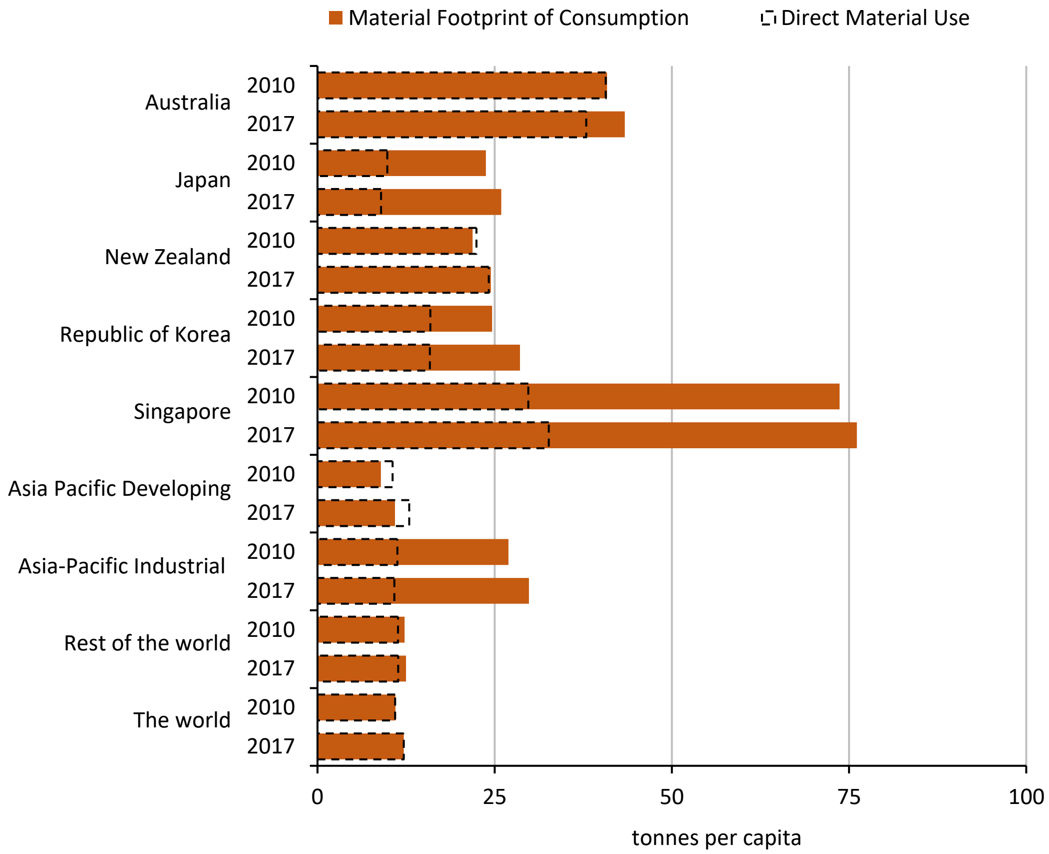


Figure 46 Material footprint per capita compared to domestic material consumption per capita, Asia Pacific industrialized countries (2010, 2017)

Figure 46 compared the material footprint per capita and the DMC per capita of the Asia Pacific industrialized countries as well as at regional and global level for 2010 and 2017. The material footprint per capita for all the Asia Pacific industrialized countries is higher than the DMC per capita. Moreover, the material footprint per capita of all the Asia Pacific industrialized countries has continued to increase which shows the intensive use of material in their production sector. The regional material footprint per capita of the Asia Pacific industrialized countries has also increased as strongly reflected by the country-wise statistics in the region. Moreover, the overall material footprint per capita of the Asia Pacific industrialized region is highest when compared to the Asia Pacific developing region, the rest of the world, and the entire world.

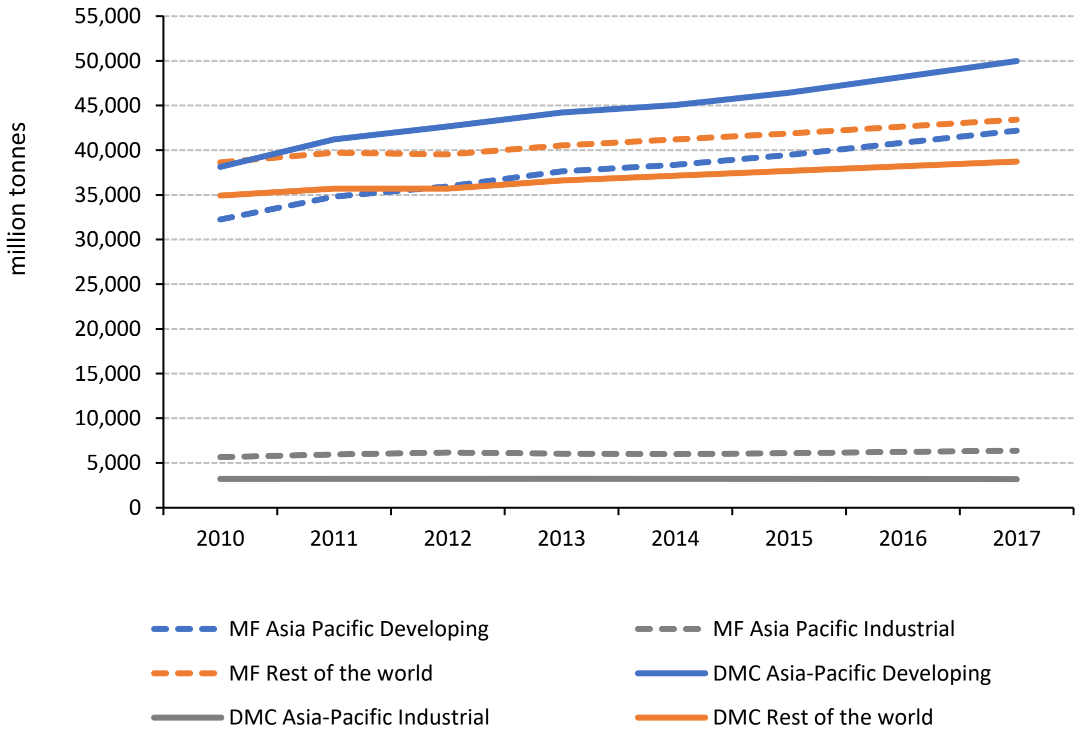


Figure 47 Material footprint compared to domestic material consumption for Asia Pacific developing and industrial countries, and rest of the world (2010, 2017)

Figure 47 shows the comparison of total DMC (million tonnes) to the total material footprint of consumption (million tonnes) for the Asia Pacific region and the rest of the world. It can be seen from Figure 50 that the Asia Pacific developing has the highest total DMC with a higher overall increasing growth rate as compared to the rest of the world. On the other hand, total regional DMC in the Asia Pacific industrialized countries shows a decreasing trend. In terms of the material footprint of consumption, the Asia Pacific region's contribution to the rest of the world's material standard of living has also increased, as seen by the region's expanding disparity between territorial material use and material footprint of consumption.

3.3.3 Water footprint

A country's water footprint is equal to the entire volume of water utilized, directly or indirectly, to generate the goods and services consumed by its citizens (Chapagain and Hoekstra, 2004). Pre-calculated data for all the countries under consideration from 1990 to 2015 is available at Eora global, multi-regional input-output framework developed by the University of Sydney (Lenzen et al., 2013; Eora global, 2021). In this report, pre-calculated data of total water footprint was used for illustrating country profiles. The overall profile of Asia Pacific region along with the top seven countries having the highest water footprint are shown in **Figure 48**. China is the leading country in water footprint consumption followed by India. These two countries are consuming more than half of all the remaining nations. Agriculture is the main sector that uses the most of soil moisture. The domestic sector is fully dependent on mainly on groundwater and surface water. In the year 2013, China's water footprint was the highest. However, in the year 2015, China, India, and Indonesia showed a slight decrease as compared to the normal trend. That is why the overall water footprint for the Asia Pacific countries was showing a decrease in water footprint as compared to the year 2014.

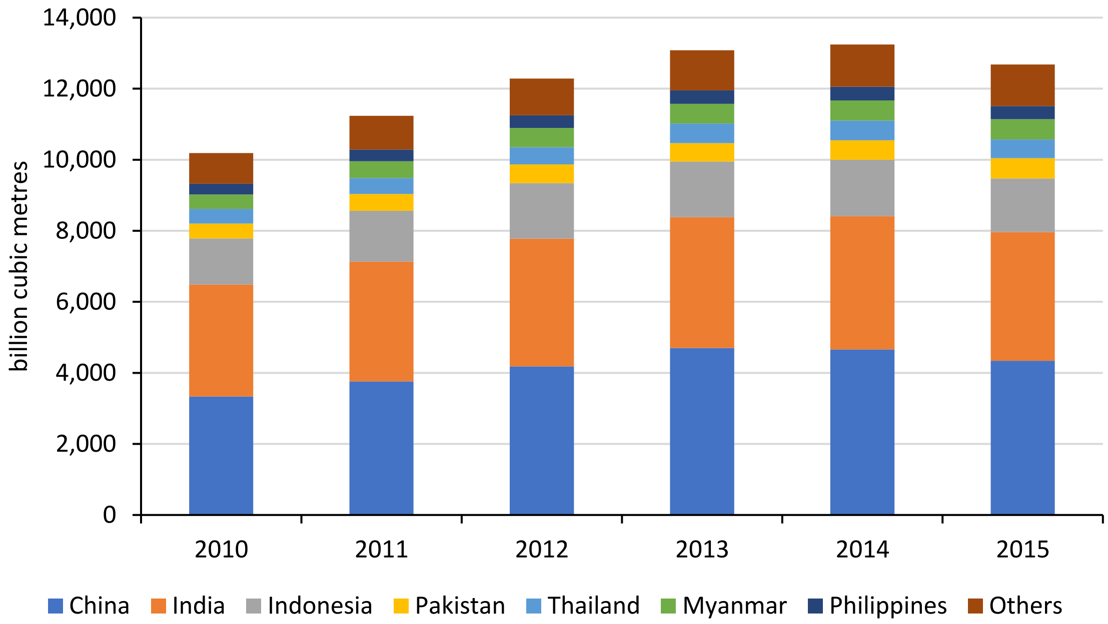


Figure 48 Water footprint, Asia Pacific region (2010, 2015)

3.4 Trade dependency

Over the years, international trade has been increasing due to the wave of globalization. The policy framework is critical in determining whether a country is a net importer or net exporter of primary resources. Importer countries can minimize their reliance on imported primary resources by increasing resource productivity, and exporter countries may adopt measures that increase export diversification. It is also important for the prevention of the Dutch Disease (an economic phenomenon entailing rapid development of one sector while declining in other sectors) via reducing the serious imbalances of payments between countries' unit prices of imports and exports.

All selected 18 countries in the Asia Pacific region are developing countries that continued to show a trend towards increasing net imports indicating that the resources in the region were no longer sufficient to support the emerging lifestyle and growing economic activity. Data for physical trade balance is sourced from the CSIRO; import and export prices are sourced from the UNCTADstat (CSIRO, 2017; UNCTADstat, 2021). For further analysis of trade dependency, it is recommended to use the import and export prices by classification of materials (biomass, fossil fuels, metal ores, and non-metallic minerals). The analysis will help to develop a better understanding and effective strategies.

Fossil fuels (42%) and metal ores (40%) were the two main net imports of the developing countries (see **Figure 49**). There was relatively consistent growth in net exports of biomass during 2010 to 2017, an average of 18%. The unit prices for imports and exports were quite similar in most countries. This implied the strong manufacturing in the region. Furthermore, the developing countries decreased the exports of low-price primary materials (such as unprocessed materials) and were more focused on selling mostly final goods (such as machinery and vehicle).

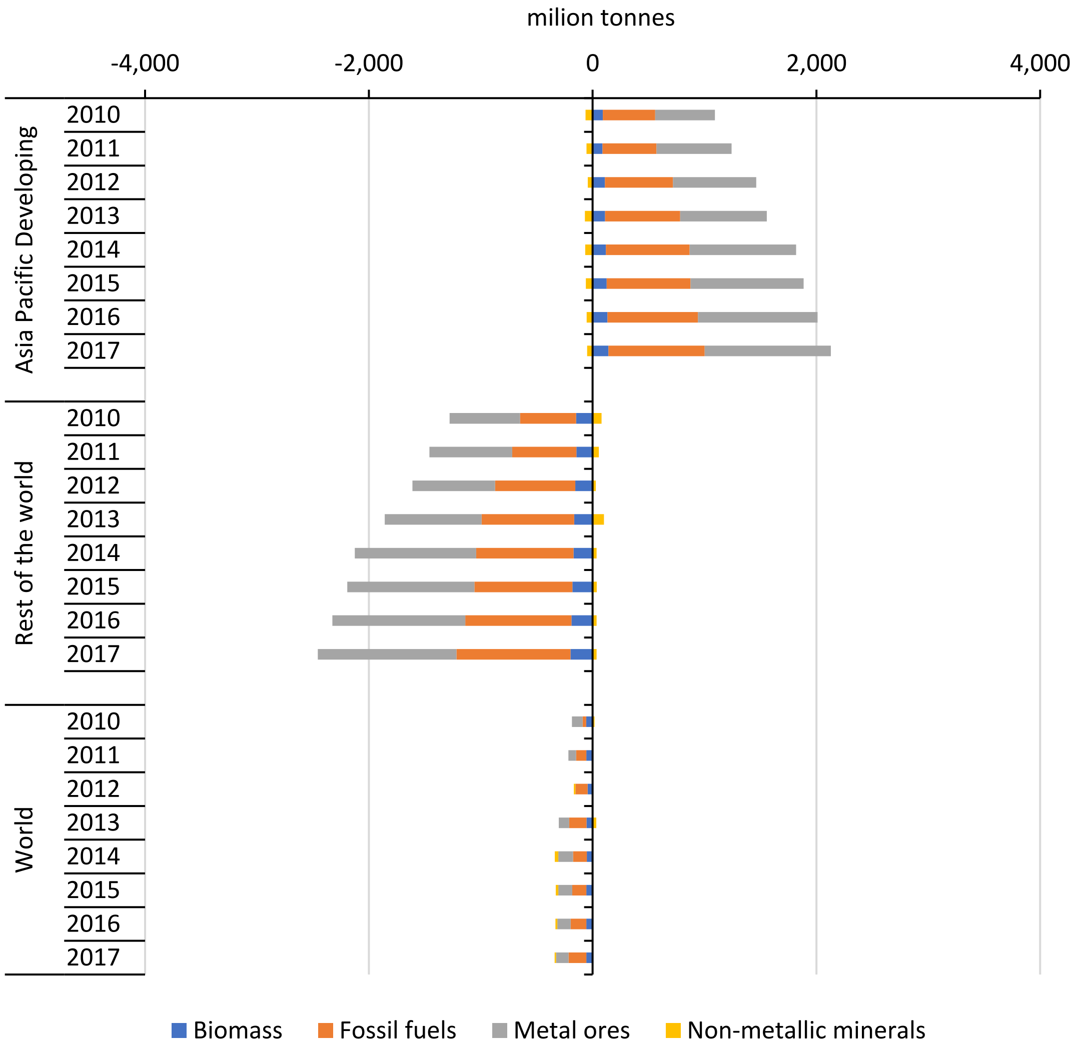


Figure 49 Physical trade balance by material category, Asia Pacific countries and rest of the world (2010 to 2017)

3.4.1 Physical trade balance

To determine whether a country is an importer or exporter, physical trade balance (PTB) is a selected indicator representing the trade status. The PTB measures material flows by subtracting the exports from the imports (in metric tonnes) and in this report, it is based on direct material use. The PTB provides information on whether a country depends on resources from abroad (positive PTB; a net importer) or supplies physical goods to the world market (negative PTB; a net exporter).

Figure 50 shows the PTB of the world by four main material categories. The world was consistently a net exporter of fossil fuels and biomass. Only in 2013, the world's net imports of non-metallic minerals jumped to 12% after decreasing in 2012. In terms of net importer, China had the largest share accounting for 64% of the Asia Pacific developing countries' net imports in 2017 with an average increase of 7% from 2010 to 2017. The largest material category exported by China in 2017 was metal ores (56%) followed by fossil fuels (31%), biomass (11%), and non-metallic minerals (2%). However, China's coal DMC declined by 4% for the first time in 2014, then 5% in 2015. This was due to various reasons, for example, banning on using low-quality coal; a climate change agreement in Beijing; declining energy intensity; slowing down of economic growth in heavy industries with high coal consumption intensity; and promoting the usage of renewable energy sources (Tang et al., 2018).

The Asia Pacific developing countries were net importers while the rest of world was a net exporter (see **Figure 50**). Growth in imports of Asia Pacific developing countries over the period of 2010 to 2017 increased from 2,304 to 3,678 million tonnes. It was apparent that by 2017, the largest share of imports was fossil fuels (42%) which increased by 6% on average over the same period. Biomass constituted the same share (12%) of imports since 2011. On the other hand, total imports of rest of the world rose by 3%, on average, during 2010 to 2017. Half of its share in 2017 was fossil fuels followed by metal ores (27%), biomass (15%), and non-metallic minerals (8%). These are in line with the global shift of materials- and energy-intensive processes to emerging Asia.

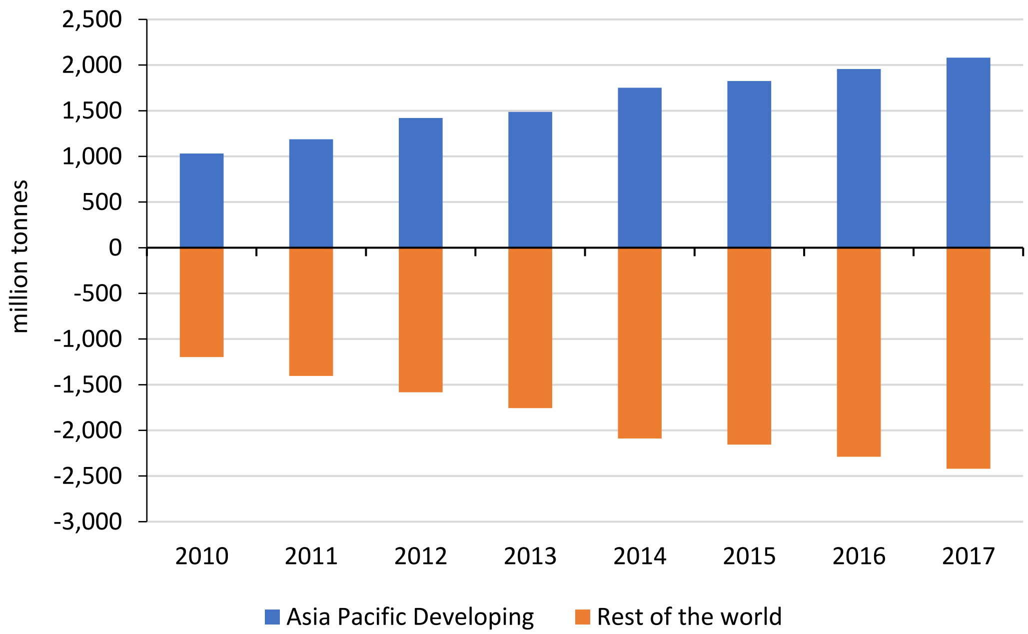


Figure 50 Physical trade balance, Asia Pacific countries and rest of world (2010 to 2017)

Figure 51 demonstrates the major net physical trade flows of countries in the Asia Pacific region. Major net importers were China and India whereas the major net exporter was Indonesia. In 2015, the lower world crude oil prices contributed significantly to the contraction of exports of petroleum gases and oil in Malaysia (IMF, 2015). This led to a decline in export values of the country changing it from a marginal net exporter to a major net importer. Similarly, Vietnam became a net importer since it rose dramatically with its coal imports by 92% from 2014 to 2015 when a series of thermal power plants started operation (Ha-Duong et al., 2016).

China had the highest absolute values of PTB (64%) in 2017. China contributed over 60% of the regional total imports and India accounted for 17% of the total, while no other countries accounted for more than 4% of the total. China's net imports grew steadily with the average of 6.7% since 2010 same as India had growth in imports averaged 6.8%. Indonesia's exports rose only 3% on the average from 2010 to 2017 since the total exports decreased by 28% in 2014. This caused by the Indonesian government imposed a ban on the export of unprocessed minerals such as copper, nickel, iron, lead, zinc, and bauxite (OECD, 2016).

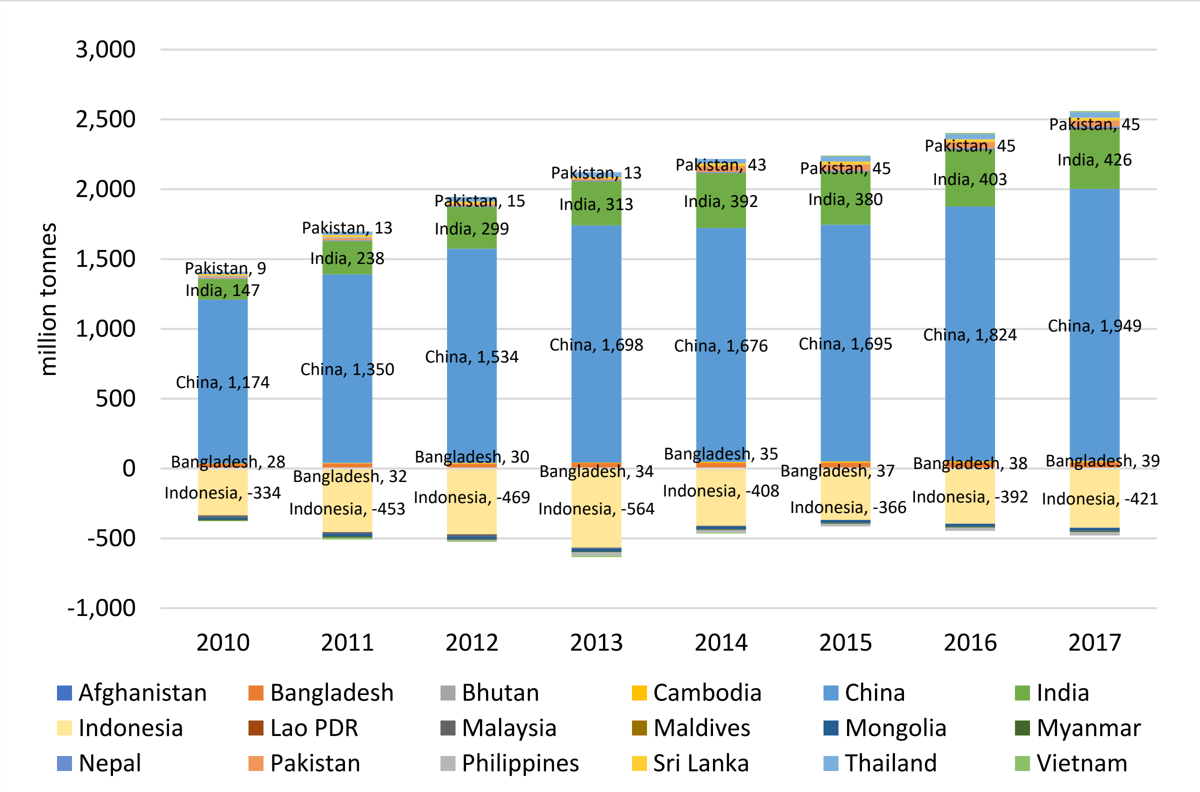


Figure 51 Physical trade balance, Asia Pacific countries (2010 to 2017)

Considering the PTB in terms of per capita indicates how much each person in the country is dependent on material resources. China was a significant net importer of materials in actual tonnes per capita term in developing countries with the highest population in the world. China's level of net imports increased from 1.1 tonnes per capita to 1.7 tonnes per capita between 2010 and 2017. By 2017, Mongolia and Myanmar tripled their net imports level from 2010 to 1.5 and 0.2 tonnes per capita, respectively (CSIRO, 2017). On the other hand, Lao PDR and the Philippines doubled their net exports from 2010, to 0.2 and 0.7 tonnes per capita, respectively in 2017.

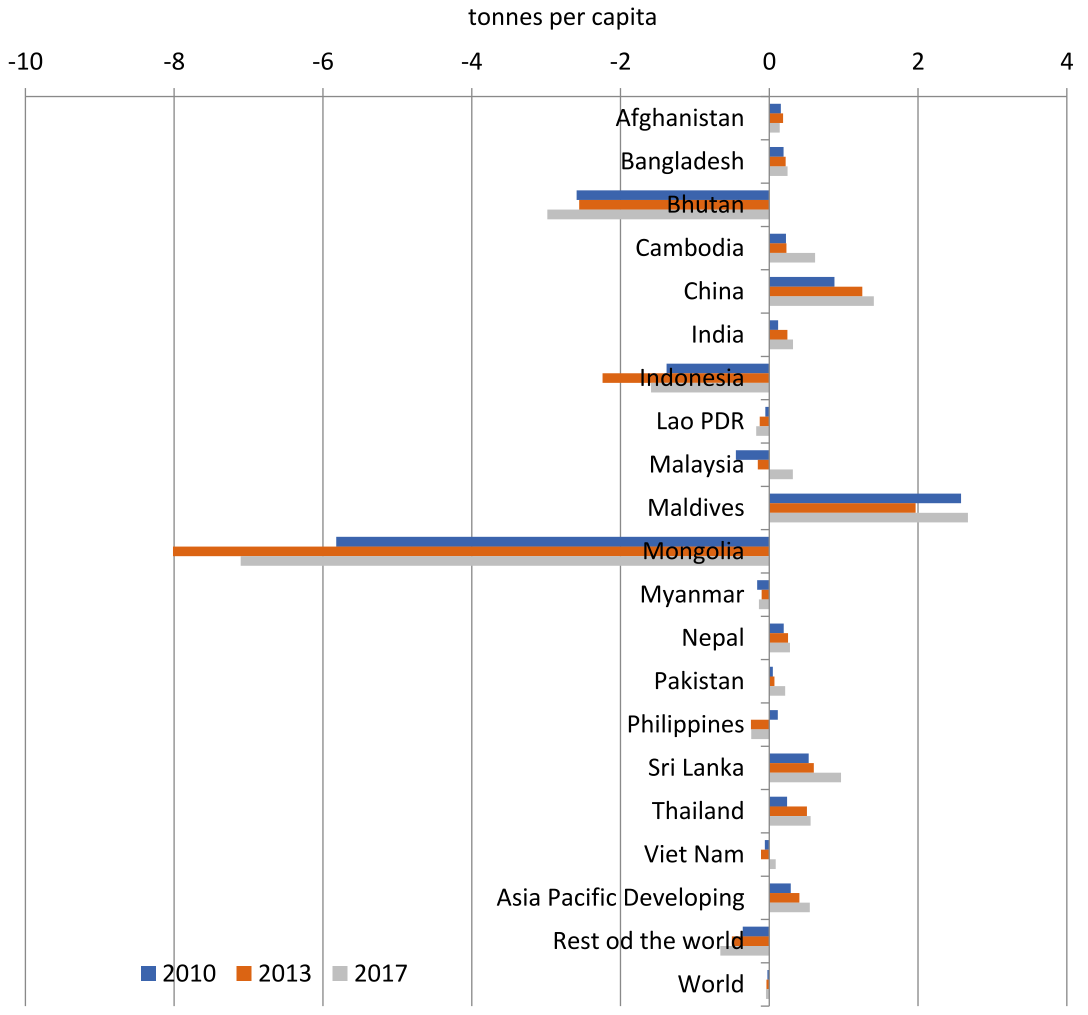


Figure 52 Physical trade balance per capita, Asia Pacific regions and rest of world (2010, 2013, and 2017)

Asia Pacific developing countries showed a growth on average of 10% in PTB per capita over the period 2010 to 2017. Developing countries, excluding Mongolia, Maldives, Indonesia, and Bhutan, all maintained PTB in the range of - 0.7 to 1.4 tonnes per capita. **Figure 52** clearly shows that the nations with small populations (Mongolia, Maldives, and Bhutan) had the extremes of PTB per capita as both net importers and net exporters. In case of Mongolia, it had a potential to improve its economy by exporting coal to the neighboring market since Mongolia is a landlocked country with a substantial reserve of high-grade coal. That is why the largest material category exported in 2017 was coal (61% of net exports), followed by ferrous ores (27%) and non-ferrous ores (6%) (CSIRO, 2017). China was the largest trade partner, accounting 85% of its exports and 33% of its imports in 2017.

However, when economies rely heavily on imports, it indicates that a country's economy is more reliant on foreign materials and goods and is therefore more vulnerable to the availability and cost of such imports, especially in a volatile economy. The country should explore strategies to improve resource productivity; for example, when developing policies aimed at enhancing resource efficiency, socioeconomic aspects should be examined, and the policy might be to incentivize the private and public sectors to use more efficient technologies (Stocker et al., 2016).

In contrast, growing dependence on exports may experience an obvious risk when the world price is volatile. Countries heavily reliant on exporting will face windfall incomes when prices are high whereas countries will take a hit to their balance of trade and national income when prices are low (UNEP, 2015b). The policies should focus on building resilience to economic shocks via export diversification and strengthening domestic demand (UNDP, 2011).

3.4.2 Unit price of trade

The unit price of the trade is related to countries' monetary income (expenditure) for each unit mass of exports (imports) showing the cost in kilogram. The economy will become stronger if the monetary income per unit of that country is greater than its monetary expenditure. The monetary base used is dollar at constant year 2010 exchange rate value, sourced from World Bank (2021). The same import and export volumes from previous section (PTB) were used to calculate unit price of trade.

In case of Asia Pacific developing countries, there is no characteristic pattern in unit prices for imports (UPI). Mongolia, Pakistan, and Cambodia benefited from large falls in the prices they pay for their imports in 2017 compared to 2010, declining 71%, 34%, and 32%, respectively. On the contrary, Lao PDR, Vietnam, and Maldives had to pay per kilogram of imports with increases of 172%, 58%, and 38%, respectively. Lao PDR depended significantly on imports from neighboring countries, the increase of UPI might be caused by rising tariffs and currencies of major trading partners becoming stronger (Suvannaphakdy and Toyoda, 2019; AGEP, 2018; Wongpit and Inthakesone, 2016). **Figure 53** does not show characteristic pattern in unit prices for imports (UPI) linking all countries of the developing group.

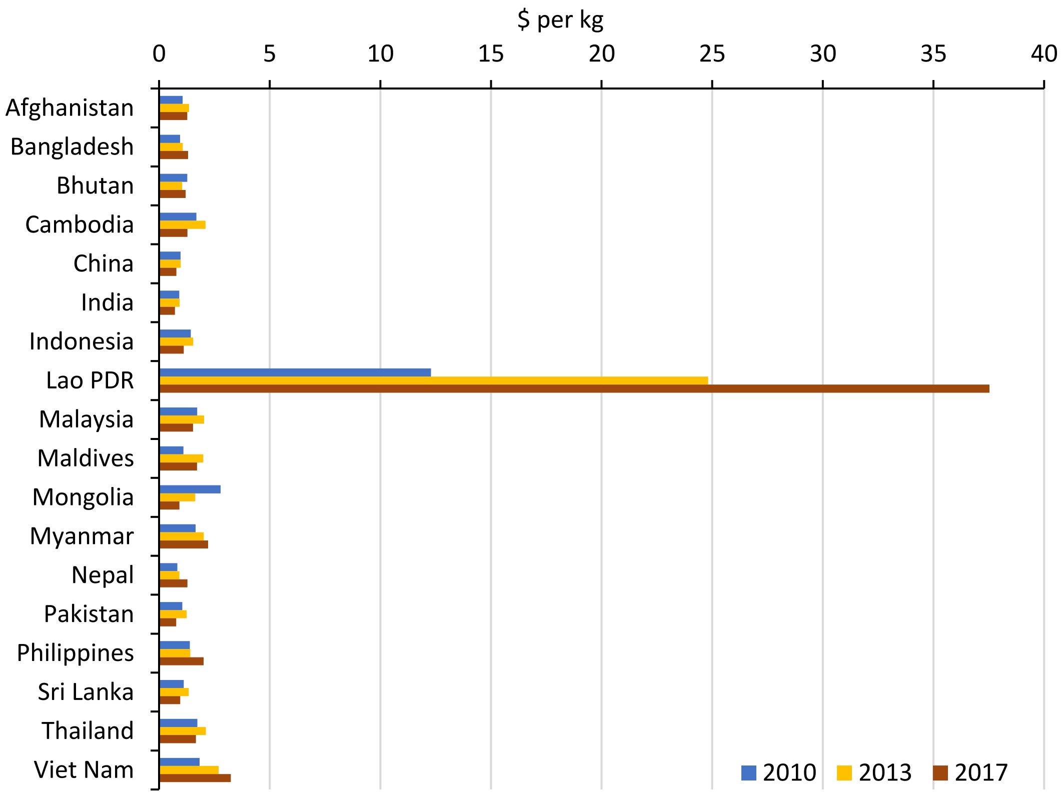


Figure 53 Unit prices of imports for Asia Pacific developing countries (2010, 2013, and 2017)

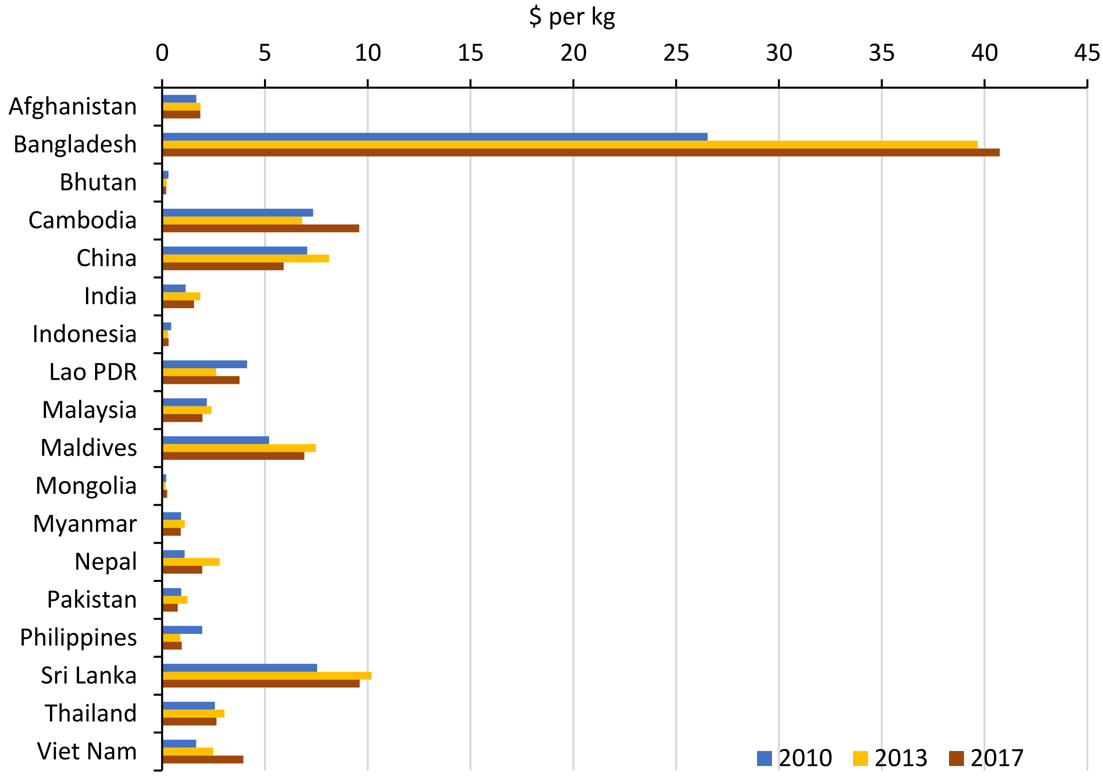


Figure 54 Unit prices of exports for Asia Pacific developing countries (2010, 2013, and 2017)

Figure 54 shows a lack of discernible pattern similar to **Figure 53** with most countries reversing trends between periods. Vietnam rapidly improved its unit prices of exports (UPE) from $1.40 per kg in 2010 to $3.33 per kg in 2017, coincident with its rise in manufacturing power. Nepal and Bangladesh reflected in a similar change in a strong improvement in their UPE with the growth of 78% and 54%, respectively over the period 2010 to 2017. By 2017, the lowest UPE was $0.17 per kg from Bhutan while Bangladesh received the highest UPE of $34.33 per kg mainly from crops (e.g., jute, tobacco, and tea). Referring to **Figure 53** and **Figure 54**, ten of the developing countries showed a continuous improvement (decrease) in the ratio of UPI: UPE. Contrarily, eight countries show a ratio increase.

Finally, the trade patterns of high volume with low value exports and high value with low volume imports will lead to an unfavorable balance of trade which will limit economic prosperity. The countries' economic development happened when using the environment and natural resources; however, in some situations, a resource-rich country still ranks as a poor income country. The Dutch disease is used to describe this anomalous phenomenon.

This happens when booming of a specific sector (i.e., natural resource sector) can lead to a decline in the development of other sectors (i.e., manufacturing sector) resulting in its other exports becoming more expensive to purchase, and its imports become cheaper. Subsequently, the countries will face lower demand for their products and have more competition from other countries. This will harm countries' long-term growth prospects and cause their economies experiencing difficulties (Stevens, 2004). The countries need to propose some policy options to prevent these outcomes, for example, ensuring sustained future growth rates by domestic public investment in infrastructure and human capital. This will yield fiscal returns in the form of non-resource revenues and stabilize net resource wealth in long term (Barder, 2006; KAPSARC, 2015)

3.5 Resources and human development

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 Pacific developing countries have shown a remarkable improvement in all three domains of HDI since the 1980s. **Figure 55** shows the relationship between material use and the human development index for the Asia Pacific developing region. The direct material consumption and material footprint have been plotted against HDI, for the concerned 18 countries.

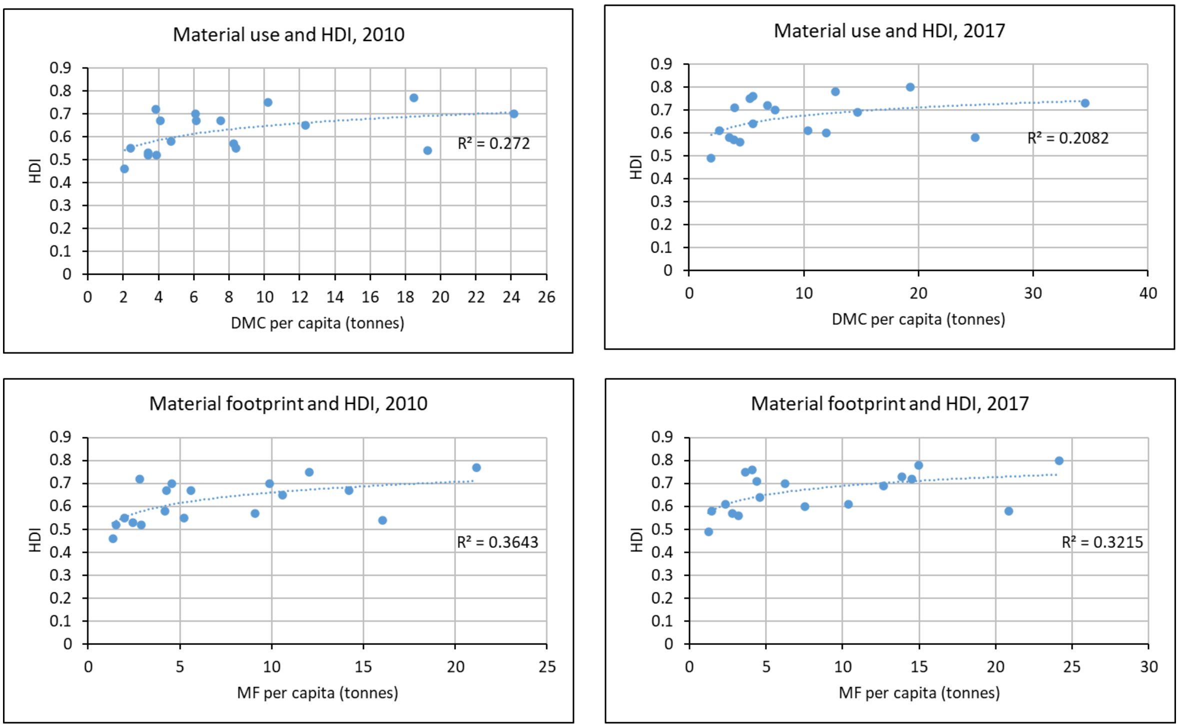


Figure 55 The relationship between material use (DMC per capita), and material footprint (MF per capita) vresus the human development index (HDI) (2010, 2017)

The plot shows that the relationship between direct material use and HDI is weaker as compared to the relationship between the material footprint of consumption and HDI. This is because two out of three components of HDI viz, life expectance and literacy rate can be improved by minimal use of material while the rise of living standards (per capita income) always depends on the increase in the resource use. In other words, the direct material use is associated to large extraction and significant manufacturing activities which has very small impact on living standards of society, while material footprint represents the material consumption for the production systems that provide substantial opportunities of employment creation and income generation. Moreover, the correlation between direct material use and HDI is not very strong and decreasing over time as the value of correlation coefficient “r” between direct material use and HDI was 0.4215 in 2010 that decreased to 0.3149 in 2017 which is near to zero, hence showing a decreasing trend. On the other hand, the correlation between material footprint and HDI is showing a much stronger. However, it is also showing a decreasing trend over the time as the value of correlation coefficient “r” between material footprint and HDI was 0.5260 in 2010 that decreased to 0.4665 in 2017.

3.5.1 Economic growth (GDP)

Gross domestic product (GDP) is the most commonly used indictor for measuring economic growth. 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 activities provide a different perspective on domestic material consumption and material footprint in concerned Asia Pacific developing countries.

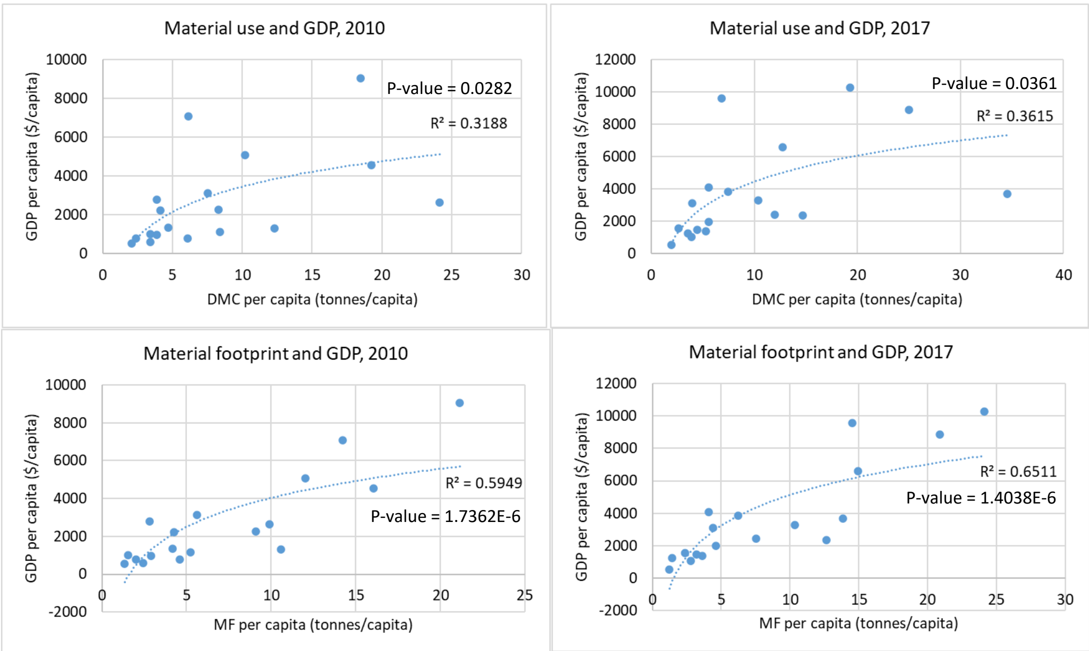


Figure 56 The relationship between material use (DMC per capita), and material footprint (MF per capita) vresus the GDP per capita (2010, 2017)

In **Figure 56**, DMC per capital (tonnes/capita) and material footprint per capita (tonnes/capita) are plotted against GDP per capita for 2010 and 2017. It can be seen that the correlation between direct material use and GDP is not very strong and decreasing over time as the value of correlation coefficient “r” between direct material use and GDP was 0.5164 in 2010 that decreased to 0.4964 in 2017 which is near to zero, hence showing a decreasing trend. On the other hand, the correlation between material footprint and GDP is showing a much stronger and increasing trend over time as the value of correlation coefficient “r” between material footprint and GDP was 0.8774 in 2010 that increased to 0.8808 in 2017.

This is because material footprint represents the material consumption for the production systems as mentioned before. It shows that as more and more material is employed in production system the Asia Pacific developing countries attain higher economic growth. However, it is unfavorable for the decoupling of material use from economic development. To achieve decoupling, the Asia Pacific developing countries have to adopt more advanced and material efficient production systems.

3.5.2 Investment and consumption

Two indicators used for the analysis: domestic material consumption per capita and foreign direct investment. The material consumption has already been discussed in detail under Section 3.1.1. The data for foreign direct investments is presented in **Figure 57** and retrieved from the World Bank databank, and net flows were presented in terms of GDP percentage. Foreign direct investments are equity flows from direct investments in the respective countries. Total capital is the sum of equity capital, earnings reinvestment, and other capital. Direct investment is a type of cross-border investment in which the investor is a resident of one country.

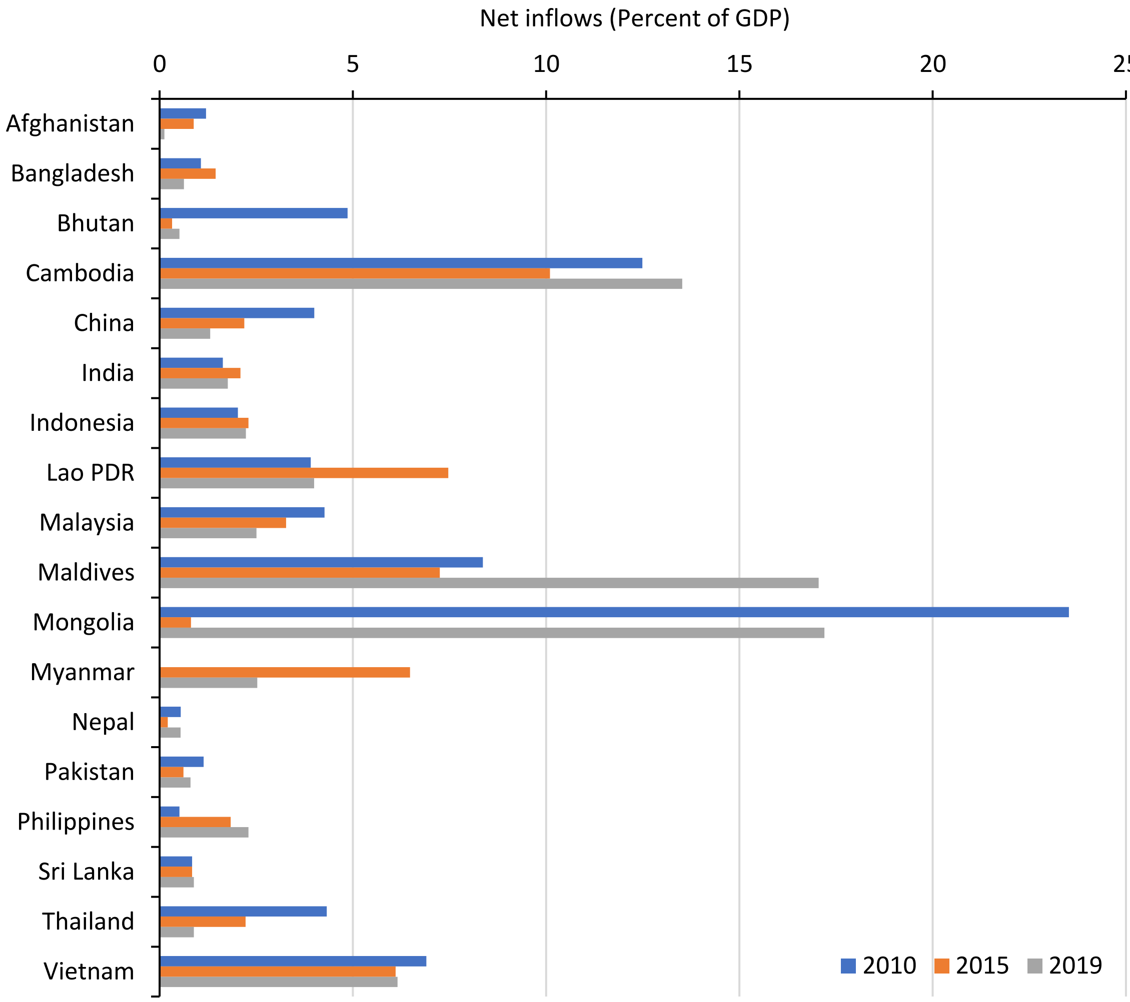


Figure 57 Foreign direct investment in Asia Pacific region

As mentioned earlier in Section 3.1.1, the highest increase in domestic material consumption was observed in Mongolia, followed by China, Lao PDR, Thailand, Vietnam, and Bhutan. However, some countries (e.g., Indonesia, the Philippines, Afghanistan, and Cambodia) had the decreasing trends in material use. On the other hand, China and India are the two biggest markets who captured the interest of investors in the Asia Pacific region, especially in the last decade as shown in **Figure 51**. Ease in policies and availability of cheap labor could be the possible reasons of this investment surge in both countries. As presented in **Figure 57**, Mongolia, Maldives, Cambodia, and Vietnam have attracted significant investment during last decade. However, a decreasing trend of foreign investors can be observed in Bhutan, Malaysia, Pakistan, and Thailand since 2010.

3.5.3 Debt, inflation

The gross debt of the government refers to the total incurred external financial obligations that are accumulated to fund expenditures in excess of generated revenues. Inflation, on the other hand, is the increase in a country's price level over time. When general prices rise, the currency unit can buy fewer products and services, showing a loss of purchasing power. The economy's medium of trade and unit of account eventually loses value.

Two indicators have been used to analyze the economic performance of selected nations in Asia Pacific region: the general government debt (expressed in terms of percentage of the GDP) and inflation rate (expressed in terms of annual percentage change in average consumer prices). The data for both indicators were retrieved from the International Monetary Fund (IMF) Database and presented for 2010, 2015, and 2018 in **Figure 58** and **Figure 59**.

The trend of both indicators — general government gross debt and inflation rate — are presented in the figures below (see **Figure 58** and **Figure 59**). In the Asia Pacific region, the general government gross debt of many countries (such as Bhutan, Maldives, Mongolia, Pakistan, and Sri Lanka) has been increased substantially since 2010 as shown in **Figure 56**. On the other hand, few of them (e.g., Thailand, India, Cambodia, and Afghanistan) showed comparatively balanced conditions in terms of the general government gross debt. However, the Philippines (from 47.6% to 37.1%), Nepal (from 35.3% to 30.1%), and Myanmar (from 52.5% to 40.4%) reduced their debts during the period of 2010 – 2018.

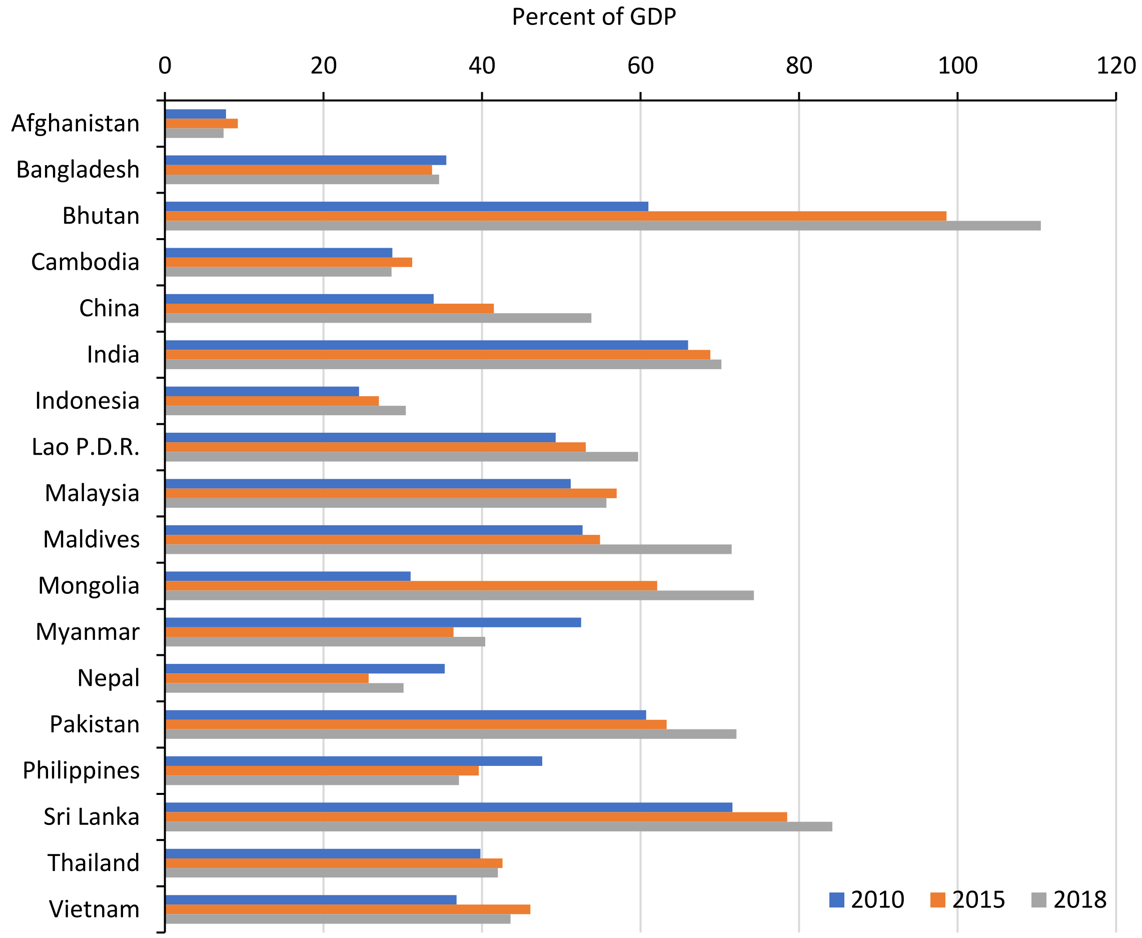


Figure 58 The general government gross debt of developing countries in Asia Pacific region

In general, the inflation rate (or annual percentage change in average consumer prices) have been reducing since 2010 in Bangladesh, India, Maldives, Nepal, and Pakistan. In 2015, Afghanistan and Thailand had shown the negative percentage change in average consumer prices. In case of Thailand, there are few main reasons of price deflation: weak consumer and investment demand; and low prices of oil and agricultural commodities. In Afghanistan, the overall growth was held back due to the uncertain security conditions and weak domestic demand along with lower commodity prices, contributed to the decline in inflation. However, Vietnam, Sri Lanka, Philippines, Myanmar, Mongolia, Lao P.D.R., China, and Cambodia have shown a decline in inflation rate during the considered period of time.

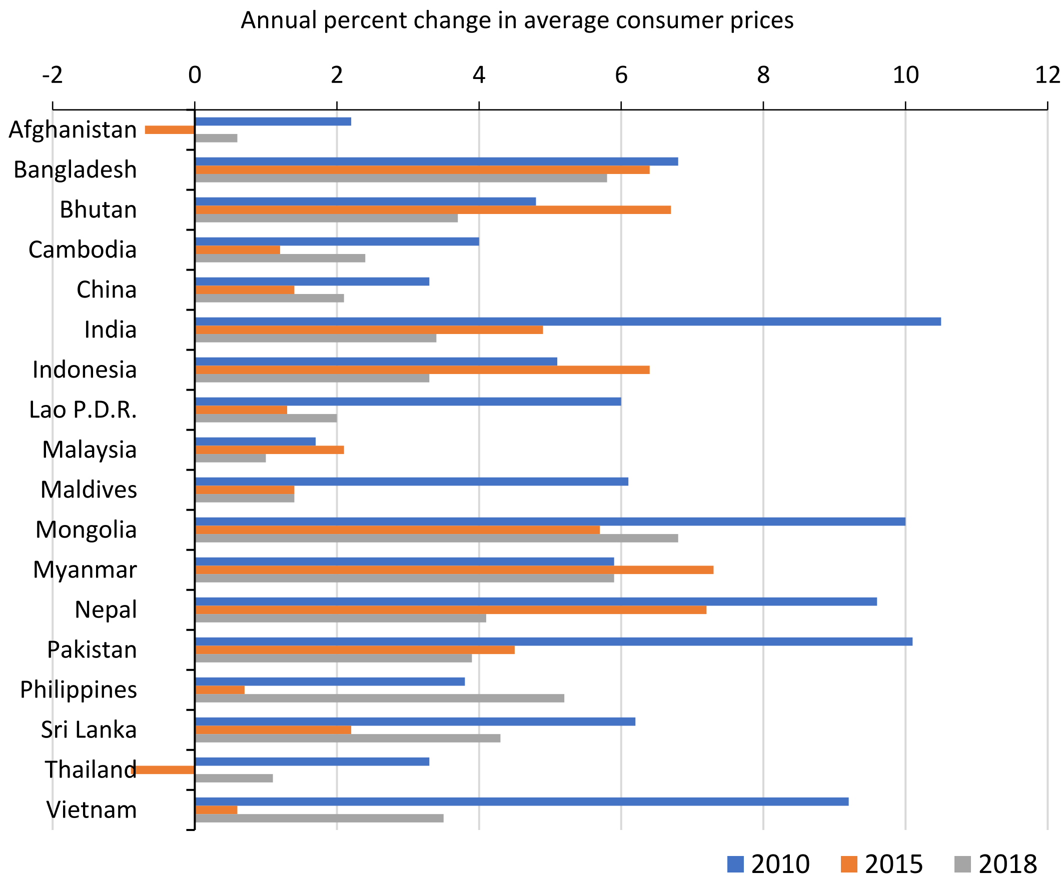


Figure 59 Inflation rate of the developing countries in Asia Pacific region

3.5.4 Access to energy, water, sanitation

To improve the standard of living which is related to human development, provision of access to electricity, water, and sanitation are taken into consideration. These three indicators are correlated with not only the standard of living (Rao and Pachauri, 2017) but also economic development (Sušnik and Van der Zaag, 2017; Burke et al., 2018).

Access to electricity

This indicator is measured as the percentage of people with access to electricity. Data on access to electricity from 2000 to 2019 of 18 countries in the Asia Pacific region was obtained from World Bank (World Bank, 2019). Missing data were filled by linear interpolation technique. Access to electricity is also correlated with economic growth.

The percentage of people with access to electricity has been increased for all 18 countries over the 20 years as illustrated in **Figure 60**. Bhutan, China, Lao PDR, Maldives, Malaysia, Sri Lanka, and Thailand have 100% of people with access to electricity. Afghanistan has made the greatest progress over the 20 years from almost none to nearly full access to electricity.

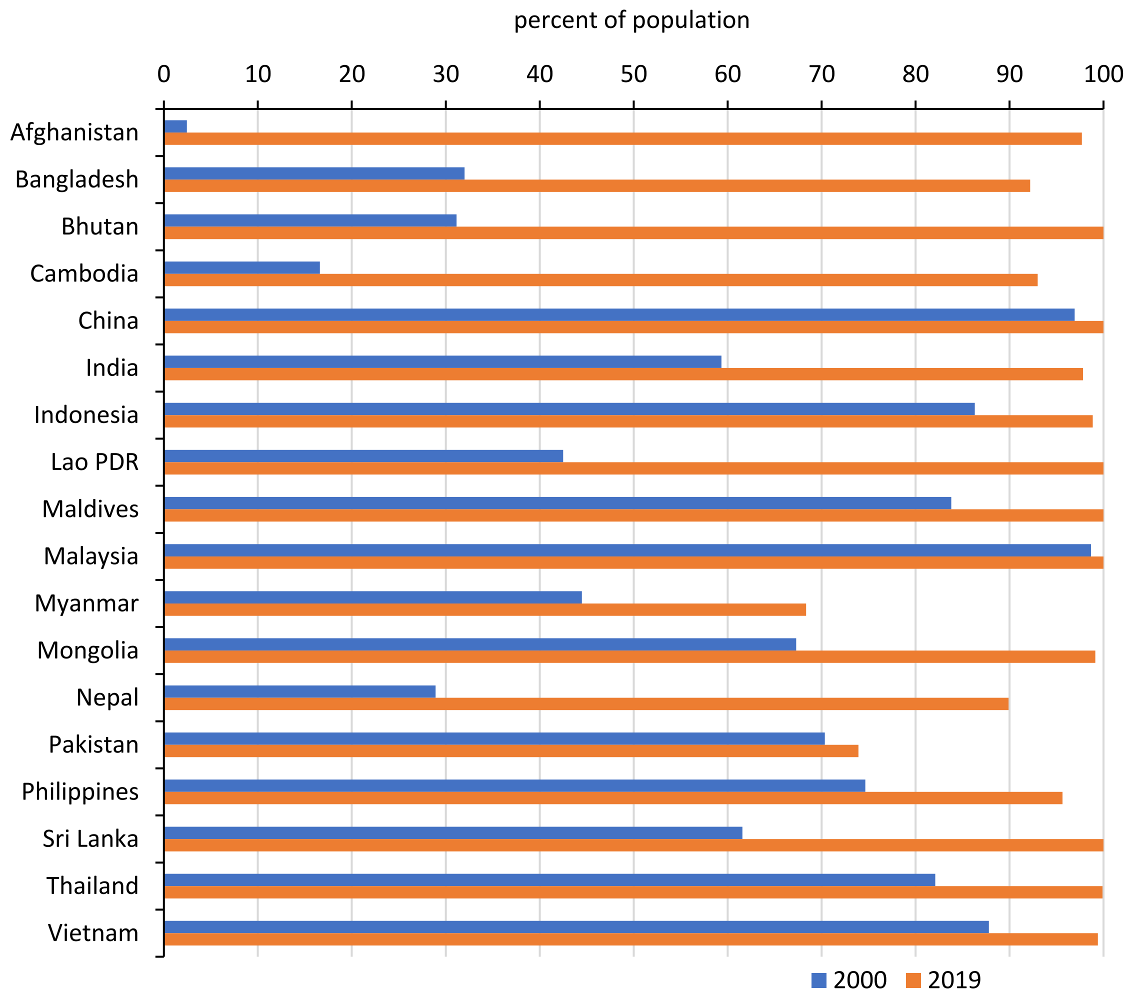


Figure 60 Access to percentage of population to electricity in Asia Pacific region, 2000 – 2019

Access to water

Access to water means access to drinking water services. It is measured as the percentage of people with access to drink water services. Data of people using safely managed drinking water services from 2000 to 2020 of 14 countries in the Asia Pacific region was obtained from the Global SDG Indicators Database (United Nations, 2021). The data of the remaining four countries under consideration is missing.

The percentage of people with access to drink water services have been increased for 14 countries over the 20 years excluding Nepal and Pakistan as shown in **Figure 61**. China is the leading country with highest access to drink water services in 2020, at 95% of population following by the Maldives and Sri Lanka. These three countries have their per capita income greater than the average income of the region that could help to achieve to drink water service. Significantly progress on increasing access to drink water services has been observed in India and Mongolia.

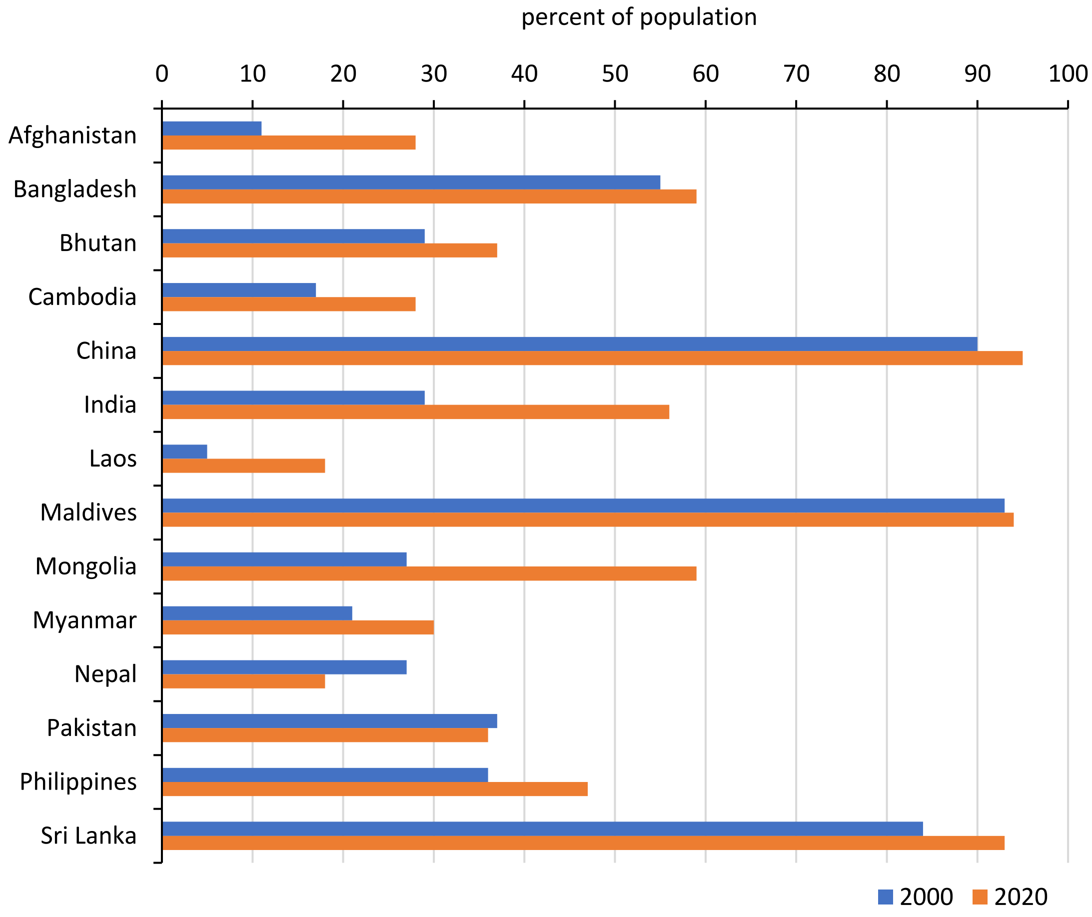


Figure 61 Access to percentage of population to drinking water services, 2000 – 2020

Access to sanitation

Access to sanitation means access to sanitation services. It is measured as the percentage of people with access to sanitation services. The sanitation facility is not shared with other households and excreta are safely disposed of in situ or treated off site. Data of people using sanitation services from 2000 to 2020 of 11 countries in the Asia Pacific region was obtained from Global SDG Indicators Database (United Nations, 2021). The data of the remaining seven countries under consideration is missing.

The percentage of people with access to sanitation services has been increased for all 11 countries over the 20 years as illustrated in **Figure 62**. The Maldives has been reached at the highest percentage of people with access to sanitation services, at almost 80% of the population.

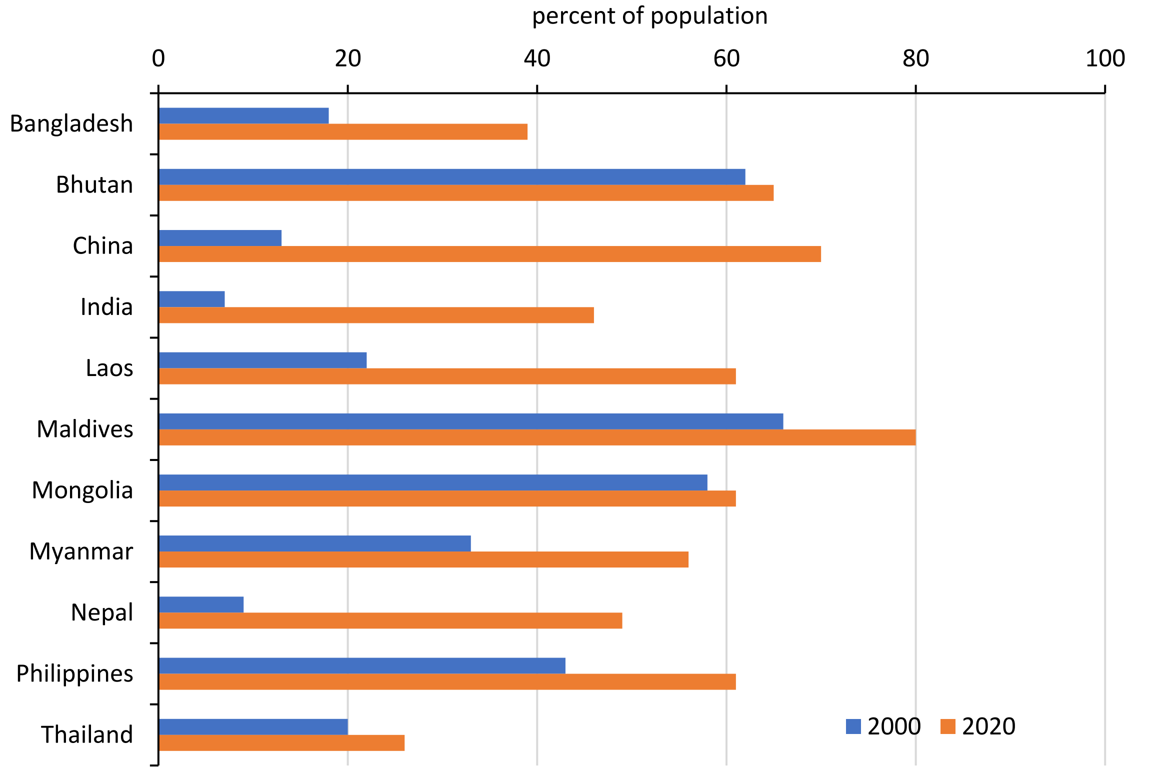


Figure 62 Access to percentage of population to sanitation services, 2000 – 2020

3.6 Inclusive green recovery

During the period of disaster/crisis, the financial supports provided to recover while focusing the environmentally friendly approaches are termed as green stimulus (UNEP, 2020b). In this report, a focus is put on fiscal supports for a COVID crisis and its effect on natural capital and natural budget including in energy, transportation, building, and research and development sectors. Overall, global green recovery spending has been insufficient to address the global challenges of climate change, environmental degradation, and pollution. O'Callaghan and

Murdock (2021) raised the following key questions, while highlighting the dire need for prompt response by the countries to align for the sustainable recovery:

1. What is at stake as governments pour resources into COVID-19 recovery in unprecedented amounts?
2. What spending strategies could help the economy recover while also ensuring the environment's long-term viability?
3. What role does recovery spending play in alleviating COVID-19-related inequalities?
4. What kind of recovery investments are countries making now to combat climate change, environmental degradation, and pollution?
5. What else can be done to achieve a long-term, fair recovery?

3.6.1 COVID spending

In 2020, the global economy shrank by approximately 3.5% due to the pandemic (IMF, 2021). The lockdown measures have crippled the economic activities; consequently, depreciating or at least burdening the countries through unemployment, wage cuts, and disease burden. The data for COVID spending was retrieved from the International Monetary Fund (IMF) database, which summarizes the key fiscal measures taken by governments in response to the COVID-19 pandemic (FAD, 2021). The database categorizes different types of fiscal support (i.e., equity, loans, and guarantees, and additional spending/forgone revenues) while focusing the discretionary measures that supplement existing automatic stabilizers.

The equity, loans, and guarantees are different forms of assistance provided to beneficiaries for investment in research and innovation. The guarantees are provided to beneficiaries so that they can borrow loans from financial institutions at better conditions. On the other hand, temporary tax cuts and liquidity support, such as loans, guarantees, and public sector capital injections, are examples of extra spending or forgone revenue. The data in **Figure 63** shows that countries such as Thailand (15.6%), Mongolia (14.7%), Malaysia (8.7%), India (8.7%), Maldives (6.9%), Cambodia (6.4%), China (6.1%), and Indonesia (5.4%) have devoted significant resources according to their capacities in recovery measures. However, developing nations like Afghanistan (2.1%), Pakistan (2.0%), Bangladesh (1.5%), Myanmar (1.0%), and Sri Lanka (0.8%) spent comparatively less, posing potential threats to health outcomes, and sustainable development; re-affirming the need for foreign assistance and/or debt relief. The data for Nepal, Bhutan, and Lao PDR was not available.

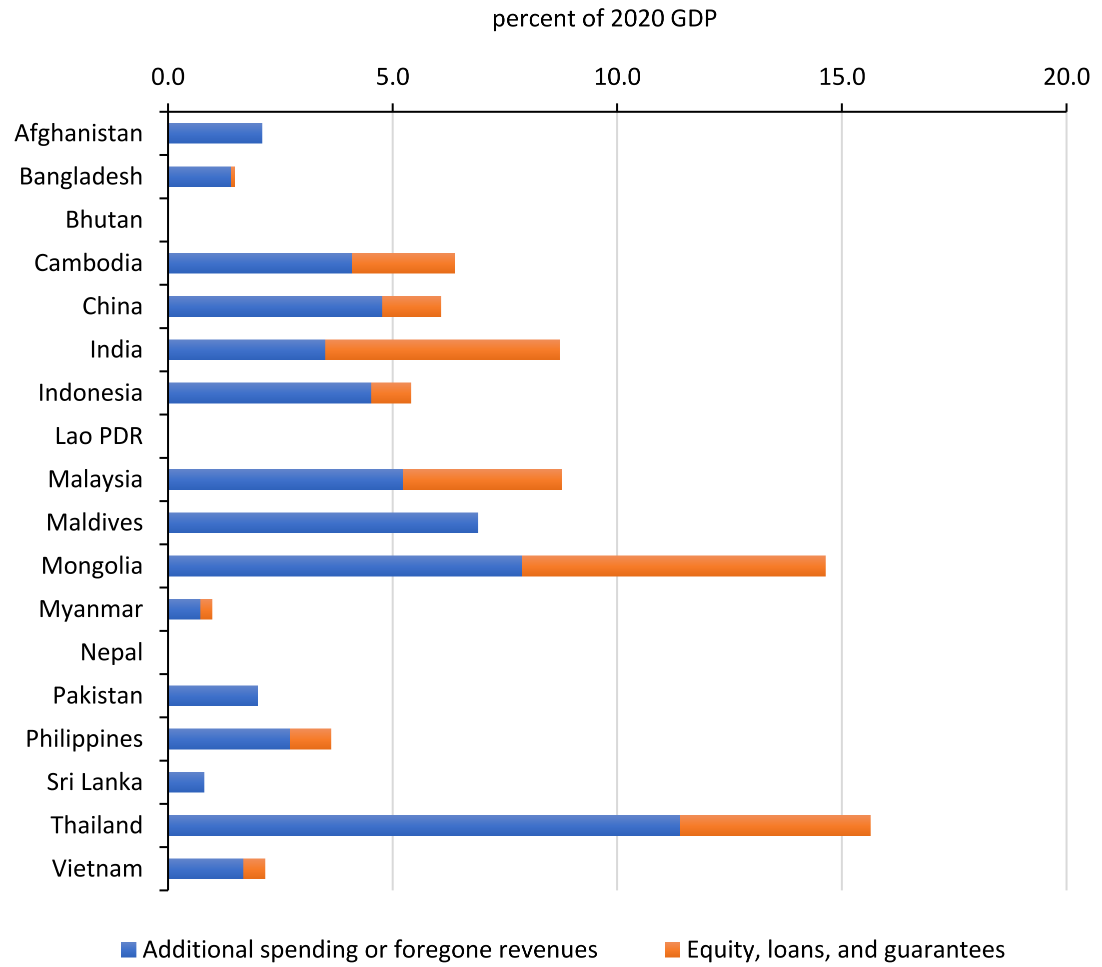


Figure 63 Country fiscal measures in response to the COVID-19 since January 2020

3.6.2 Natural capital

Natural capital plays a vital role in nourishing the global economies. It is now becoming more and more important than ever to take decisive measures against deforestation or natural disasters to protect and rebuild it. Low skills are often required for jobs resulting from natural capital investments, which can provide employment chances for demographics that are particularly vulnerable during the epidemic (Edwards et al., 2013).

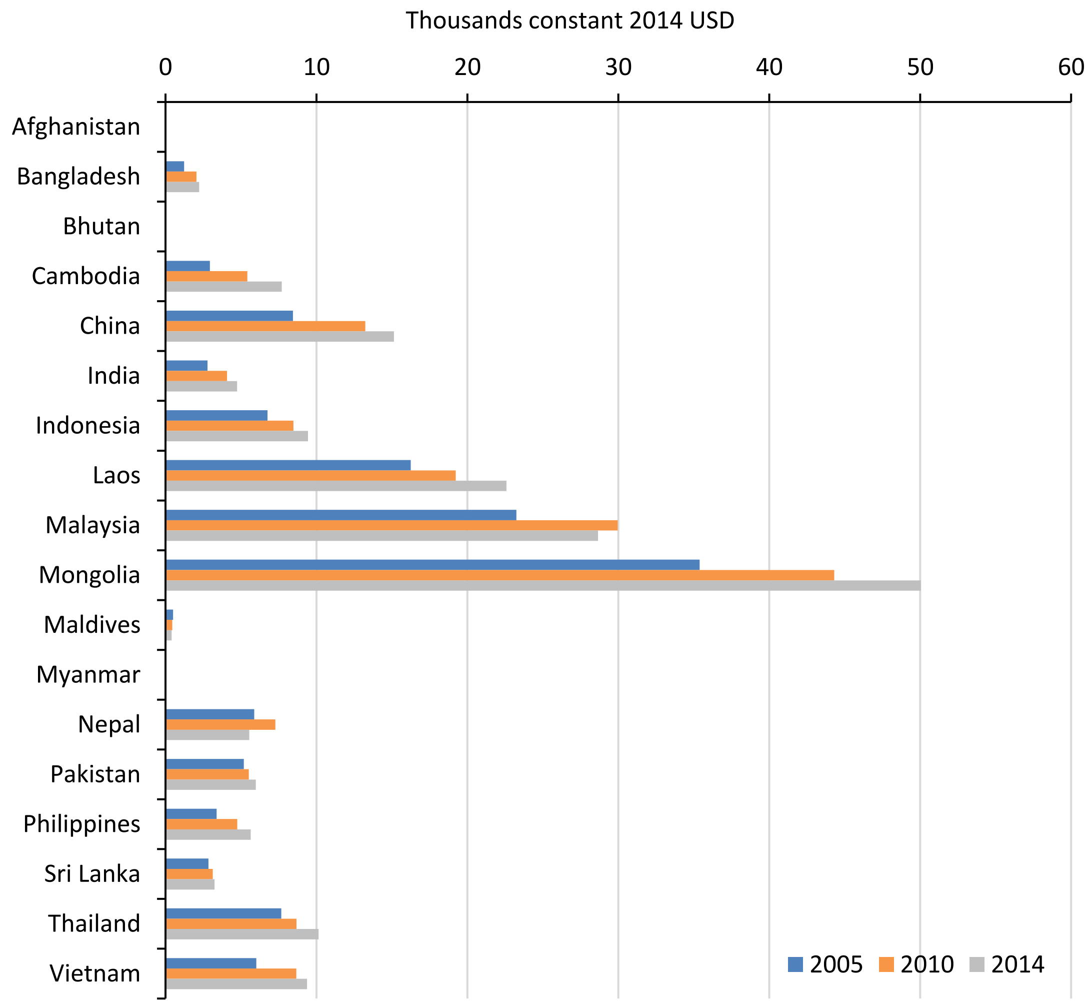


Figure 64 Natural capital of some countries in Asia pacific region

In **Figure 64**, the natural capital per capita is used as an indicator to assess the natural capital of different countries located in Asia Pacific. The indicator takes into account the value of fossil fuel energy (oil, gas, hard and soft coal), minerals (bauxite, copper, gold, iron ore, lead, nickel, phosphate, silver, tin, and zinc), agricultural land (cropland and pastureland), forests (timber and some nontimber forest products), and protected areas. Values are calculated using a country-specific GDP deflator at market exchange rates in constant 2014 US dollars (World Bank, 2020). The data for most of the countries in Asia Pacific region was missing. However, the available trends show that two of the nations affected most by COVID-19 (i.e., India and China) have the highest natural capital per capita after Mongolia.

3.6.3 Green spending

Economic thinking requires a new approach in responding to the global COVID-19 recession. Rather than just a higher GDP for next year, stimulus spending should be targeted more. Future prosperity should be prioritized by the spending consequently catalyzing the new industries in the long run. Green expenditure might assist the region in addressing the pandemic-caused recession, reducing carbon emissions, and transitioning to a healthy and resilient long-term growth path. Furthermore, as compared to traditional options, investment in green initiatives may result in more jobs not just in the short term but also in the long run (O'Callaghan et al., 2021).

The spending's data for the Asia pacific region is retrieved from the Global Recovery Observatory which tracks and assesses every individual COVID-19 related fiscal spending policy announced by the leading economies worldwide for potential impacts on the environment and the socio-economy. The data is focusing on 'recovery' spending rather than 'rescue' spending. Each policy and its relative "greenness" based on its potential influence on long- and short-term GHG emissions, air pollution, natural capital, quality of life, inequality, and rural livelihood can further be explored on given data source. However, the three general categories (i.e., green, recovery, and total spending) are included in this analysis (O'Callaghan et al., 2020).

In **Figure 65**, the data for Afghanistan, Bhutan, Cambodia, Lao PDR, Maldives, Myanmar, Nepal, and Sri Lanka was missing as the current focus of the Global Recovery Observatory is on the leading economies of the world. The available data shows that Malaysia has the highest total spending in the Asia Pacific region followed by Mongolia, China, and the Philippines respectively. However, the Philippines, Mongolia, and China showed highest recovery spending among all the considered nations in Asia Pacific region. On the other hand, in the Asia Pacific region, the green spending is negligible as compared to the recovery and total spending.

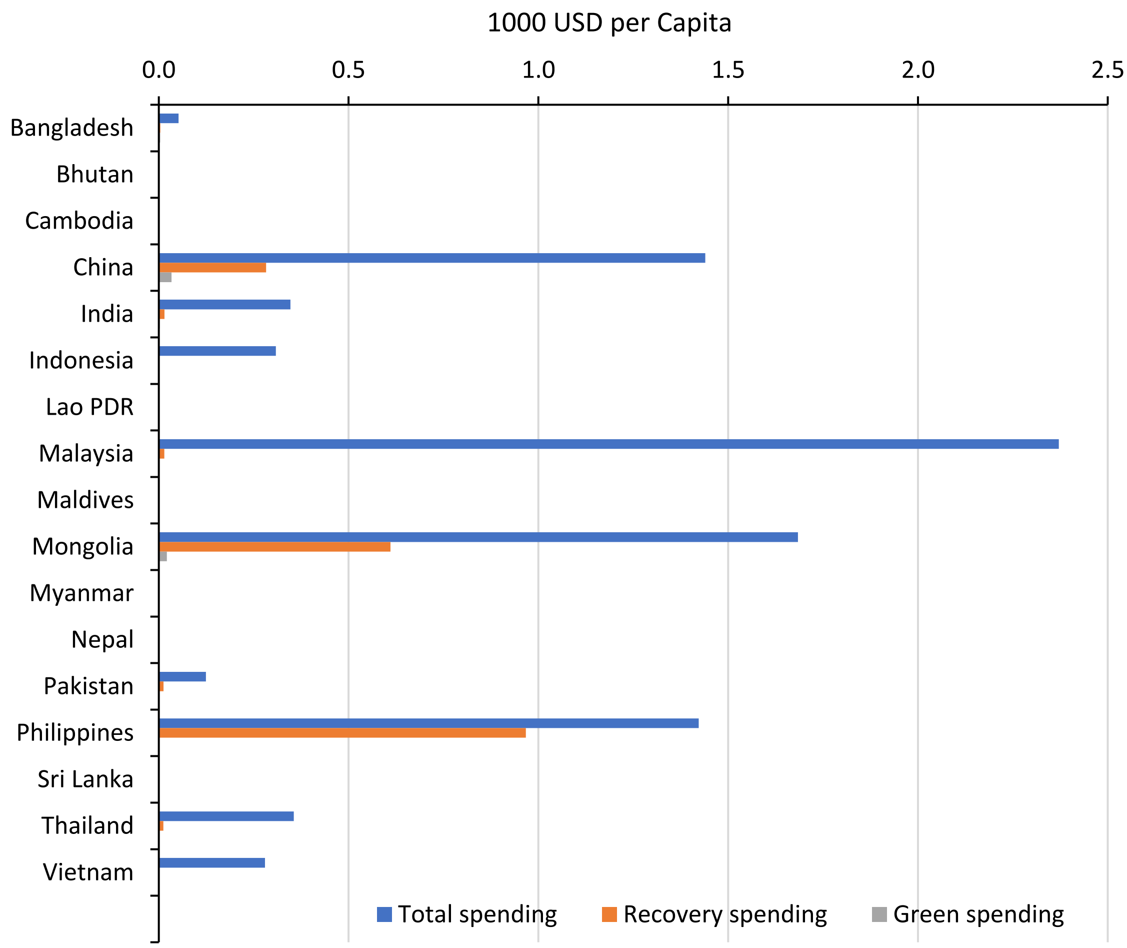
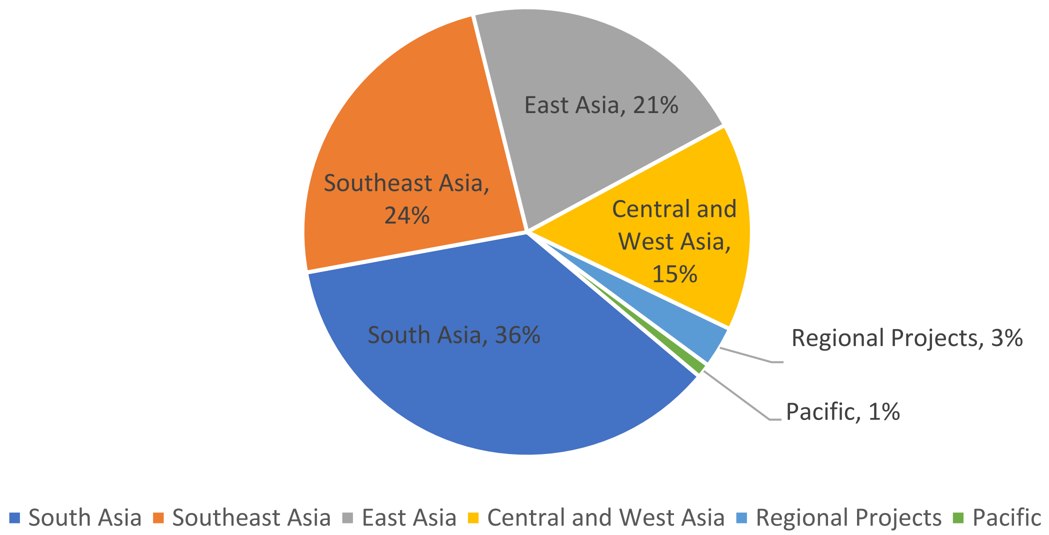


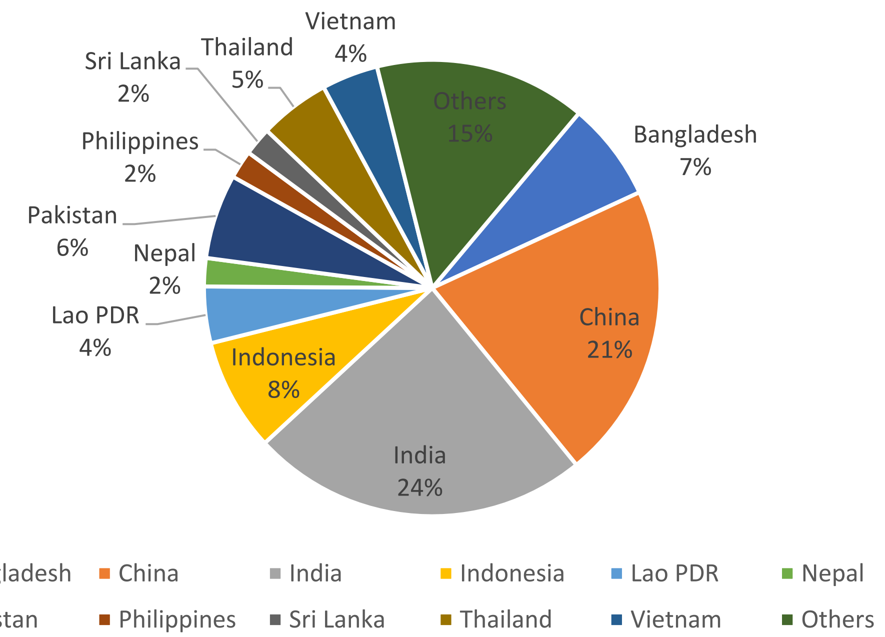
Figure 65 Green, recovery and total spending in the Asia Pacific region.

Green energy investments

Green energy is defined as energy that comes from natural or renewable resources; therefore, it has less environmental impacts leading to a cleaner and more sustainable energy. Green energy investments have high potential to attract the private investors and play a crucial role in economy-wide decarbonization. New renewable generating, transmission investments, distribution (including smart grids), and energy storage options can all provide significant benefits. When compared to typical energy programs, employment prospects for these investments can be substantial, particularly in the short term (Dvořák et al., 2017).



a)



b)

Figure 66 Clean energy and climate mitigation investments by subregion and country, 2005–2019 (ADB, 2021a).

The ADBs invested approximately 25 billion USD from 2005 to 2019 for clean energy and climate mitigation in Asia and the Pacific. For the period 2005–2019, the energy sector (mainly hydroelectric facilities, various small solar and wind projects, and geothermal) account for almost 85% of total clean energy and climate mitigation investments. As shown in **Figure 66**, the highest share of total clean energy and climate mitigation investments were received by South Asia (36%) followed by Southeast Asia (24%), East Asia (21%), and Central Asia (15%). In the South Asian region, India is one of the major recipients of the investment (24%) of total clean energy and climate mitigation investments, followed by Bangladesh (7%). Indonesia (5%), Thailand (5%), Vietnam (4%), and the Lao PDR (4%). Significant amounts were provided by the Asian Development Bank to China (21%) in the East Asian region.

Green transport

Transport is an important sector which has the great potential to cop climate change. New technologies — including vehicle electrification and biofuel production to decrease dependency on fossil fuels — give rise to further prospects for increasing the dissemination of renewable energy. Furthermore, electrification of road transport is gaining popularity in the region. Although electromobility is not directly related to the adoption of renewables, because its influence on emissions is dependent on a country's "green" energy mix, it can signify a step away from fossil fuel consumption.

Two indicators were selected to analyze the status que of the transport sector in green perspective: electricity demand from the global EV-fleet and biofuel production in 2019 compared to consumption in 2030 under the sustainable development scenario. The data was retrieved from the International Energy Agency (IEA) data bank.

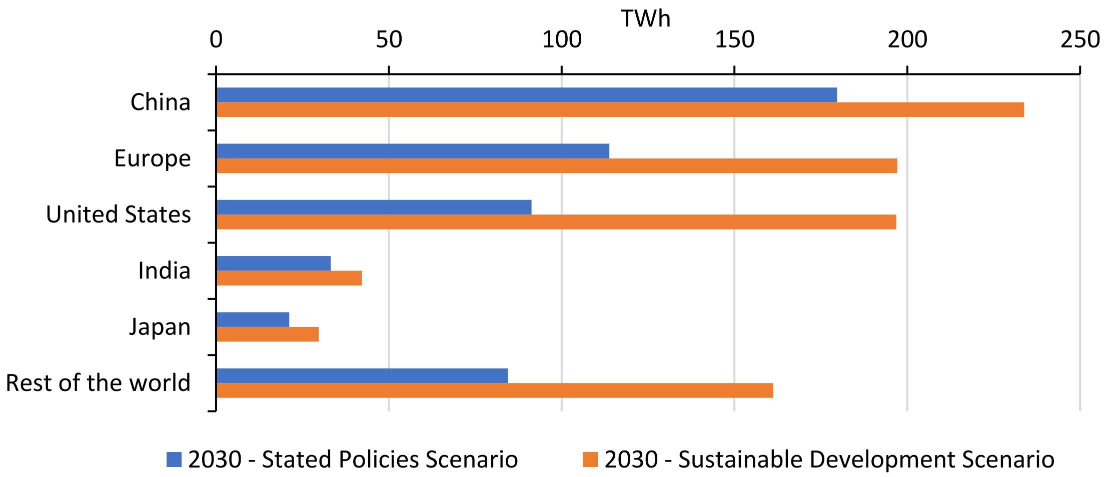


Figure 67 Electricity demand from the global EV-fleet by country or region-2030 (IEA, 2021).

As shown in **Figure 67**, in the adoption of EVs, China is a world leader followed by India in Asia Pacific region. In 2018, the estimated amount of the EV fleets on the road were around 2.3

million (i.e., around 45% of the global fleet volume) with an 80 % increase as compared to the previous year (REN21, 2019). Due to the obvious popularity of EVs, particularly in China, metal resource consumption in the transportation industry may become a major challenge for sustainable development.

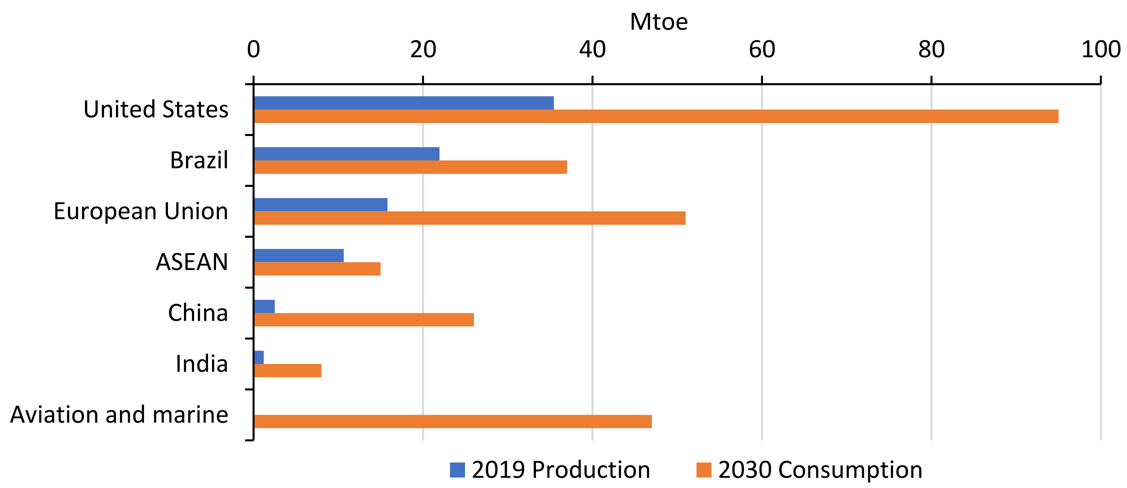


Figure 68 Biofuel production in 2019 compared to consumption in 2030 under the sustainable development scenario (IEA, 2020)

As show in **Figure 68**, China and India are not only the two key players in the Asia Pacific region but also among the top biofuel producers in the world. In ASEAN region, Thailand, Indonesia, and Philippines are among the top contributors in the production of biofuels. In 2018, the production of biofuels reached at 12 million tonnes (i.e., an increment of 2.5 million tonnes as compared to the previous year) in the region (REN21, 2019). The generation of fuel ethanol accounts for approximately 45 % of this total, with the remaining 55 % being fatty acid methyl esters (commonly known as FAME) biodiesel.

Green research and development

Green research and development or green R&D mainly put a focus on R&D investment and activities for eco-innovation and eco-friendly products. This could lead to improve productivity and efficiency on materials and resources use as well as less pollutants being emitted (Ki-Hoon and Byung, 2015). Since R&D investment programs differ from other key policy areas, support for these projects is critical for the long-term health of economies and our ability to address climate change.

The 'Dollar value of financial and technical assistance committed to developing economies' is the selected indicator to assess the green research and development in the Asia Pacific region. The dataset (ADB, 2021b) is retrieved from the Asia Development Bank-Key Indicators Database. This indicator is in accordance with the SDG Target 17.9: Enhance international support for implementing effective and targeted capacity-building in developing economies to support national plans to implement all the Sustainable Development Goals, including through North-South, South-South, and triangular cooperation. The data presented in **Figure 69** refers to the total official development assistance (i.e., the gross disbursements for technical cooperation) in Asia Pacific region.

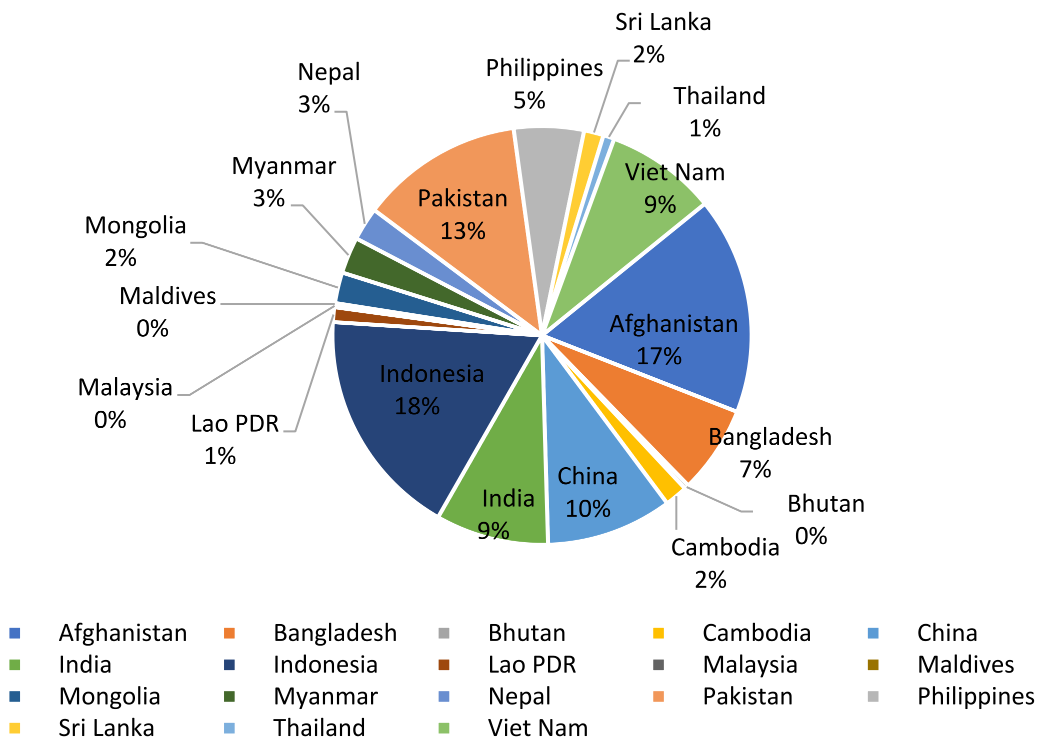


Figure 69 Financial and technical assistance committed to developing economies in Asia Pacific region, average 2010-2020 (constant 2019 million USD)

In **Figure 69**, it can be observed that substantial amounts of financial assistance have been disbursed to Indonesia (1359.9 million USD), Afghanistan (1285.2 million USD), Pakistan (965.2 million USD), China (745 million USD), India (668.2 million USD), Vietnam (656.3 million USD), and Bangladesh (518.3 million USD), and Philippines (414 million USD) during last decade of 2010-2020.

Chapter 4 Conclusion

Resource efficiency has emerged as a key challenge for the Asia Pacific region. In this report, resource efficiency indicators and relevant databases for the region have been presented. This will enable the situation awareness of resource use efficiency for economic activities that will in turn be used for decoupling the economic growth from environmental damages. The availability of a diverse range of relevant indicators and comprehensive databases would help the decision makers (both policy and businesses) to formulate a response to complex situations. This will strengthen all the stages of the policy cycle, i.e., problem identification, policy formulation, effective implementation, and continuous monitoring and evaluation.

Overall, it was revealed that the material and energy use are increasing over time. Also, the pressure in terms of pollutants and emissions is increasing under the driving force of positive economic growth in the region. Considering the resource efficiency improvement efforts, the significance of the region has been observed from the high share of resource use compared to the rest of the world. This means an improvement in the region could greatly affect global performance. GHG emissions and waste generation are also increasing in the region with time. One of the main concerns regarding waste generation is the non-availability of data for most countries. On the other hand, both water and land are mainly being used for agricultural activities. Over 24 years (1992-2015), land utilization for human activities has increased by around 25 million hectares while at the same time nearly 8 million hectares of forest has been removed.

Considering the trade balance indicators, the Asia Pacific region has come to be known as an exporter in the world where China and India are the main exporting countries. Interestingly, Bangladesh has a significantly better unit price of exports depicting an opportunity for other countries as well.

For the green recovery indicator, countries have reprogrammed their existing budgets while many countries have also created dedicated COVID-19 extrabudgetary funds. However, despite a few prominent stakeholders making significant fiscal moves toward long-term recovery, the region has so far fallen short of meeting common expectations. As the pandemic advances, officials will naturally shift their focus away from rescue efforts and toward recovery efforts. Many countries in the region with lower development indices were found to have spent less on both rescue and recovery type initiatives, thus jeopardizing poverty rates, health outcomes, and the trajectory of sustainable development in those countries, reaffirming the need for decisive steps.

Anyhow, the intensity (ratio of total material use/emissions and GDP) is improving with time showing the progress towards the decoupling. Similarly, agriculture productivity is also improving significantly. Access to electricity, water, and sanitation has also been improved meaningfully in the region.

Despite some improvements in resource efficiency, the pressure in terms of resource use and environmental damages is quite large. At this pace, the planet will not be able to meet the resource use requirements of the people. This requires escalating the efforts for improving resource efficiency in the region. The data gaps highlighted by this study, especially for the waste generation, should be filled. This report has been written keeping in mind the decision makers. Therefore, it is recommended to use the indicators and database provided by this report in the decision-making process. This will help in making informed and effective decisions to improve the resource efficiency in the region. Furthermore, there is a need to develop the regional indicators for the efficacy of public infrastructure use, circular economy performance, plastic waste generation, air and water quality, fishing, and blue economy. The database and indicators for gender equality are also suggested to be considered in future work. In the future, it is suggested that the social components of resource efficiency be expanded. It is also advised that different databases be harmonized, and different indicator results are weighted for an easy understanding of decision makers. Collaboration among multidisciplinary organizations and data harmonization is extremely necessary to develop holistic databases in the future. Therefore, enhanced collaboration is suggested to allow various institutes and organizations of the region to access and update the regional databases.

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Appendix I

Data inventory

No.	Data inventory Items	Unit/ Format	Description	Scale	Time series	Methodology/ Data Sources	Purpose of regional indicator
1	**Natural resources**						
1.1	Material use	Tonne, tonne/capita	Domestic material consumption total (tonne) and per capita (tonne/capita)	Annual/ national scale	2010-2017	United Nations Environment Programme International Resource Panel Global Material Flows Database (https://www.resourcepanel.org/global-material-flows-database)	The total domestic material consumption (DMC, tonne) and domestic material consumption per capita-DMC per capita (tonne per capita) are used as indicators to measure the material use
1.2	Renewable Energy use	Percentage (%)	The renewable energy share in total final consumption is the percentage of final consumption of energy that is derived from renewable resources.	Regional comparison	2000-2018	International Energy Agency (IEA) (https://www.iea.org/data-and-statistics) UNSD (https://unstats.un.org/unsd/energystats/data)	The indicator is used to analyze the situation of the Asia Pacific region towards renewable energy use (in terms of percentage of final consumption of energy which is derived from renewable resources).
		Percentage (%)		Country-wise comparison	2010, 2015, and 2018.	IEA (https://www.iea.org/data-and-statistics) UNSD (https://unstats.un.org/unsd/energystats/data)	
1.3	Water use (water withdrawal)	Billion cubic meters	It measures the total water withdrawal from ground and surface water resources and soil moisture is not included.	Annual/ national scale	2010-2017	Food and Agriculture Organization of the United Nations (FAO) (http://www.fao.org/aquastat/statistics/query/index.h	This indicator deals with the measure of total annual water withdrawal by the agriculture,

No.	Data inventory Items	Unit/ Format	Description	Scale	Time series	Methodology/ Data Sources	Purpose of regional indicator
						tml;jsessionid=78FFD3BAAF9A95E0880C546521126444)	industry, and domestic sectors .
	Agricultural water withdrawal	Billion cubic meters	It measures the water withdrawal for the agriculture sector only from ground and surface water resources and soil moisture is not included.	Annual/ national scale	2010-2017	FAO (http://www.fao.org/aquastat/statistics/query/index.html;jsessionid=78FFD3BAAF9A95E0880C546521126444)	The purpose of this indicator is to give a measure of the annual water withdrawal for the agriculture sector .
	Water intensity	Liter per dollar	It measures the total water withdrawal without soil moisture and GDP of a nation.	Annual/ national scale	2010-2017	FAO (http://www.fao.org/aquastat/statistics/query/index.html;jsessionid=78FFD3BAAF9A95E0880C546521126444)	The purpose of this indicator is to measure the use of water (liter) to earn a dollar
1.4	Greenhouse gas emissions (GHG)	Million metric tonne of CO_2 equivalent	The GHG total is composed of GHG totals excluding short-cycle biomass burning (such as agricultural waste burning and Savannah burning) but including other biomass burning (such as forest fires, post-burn decay, peat fires and decay of drained peatlands), all anthropogenic CH_4 sources, N_2O sources and F-gases (HFCs, PFCs and SF_6) of drained peatlands).	Annual/ national scale	2010 -2015	European Commission, Joint Research Centre (http://edgar.jrc.ec.europa.eu/)	The purpose of this indicator is to give a summation measure of all GHG emissions .

No.	Data inventory Items	Unit/ Format	Description	Scale	Time series	Methodology/ Data Sources	Purpose of regional indicator
		Million metric tonne of CO_2 equivalent	Greenhouse gas emissions from agriculture including all the emissions produced in the different agricultural activities	Annual/ national scale	2010 -2015	FAO (http://www.fao.org/) FAOSTAT Agriculture database(http://faostat3.fao.org/home/E)	To GHG emissions from agriculture within the region annually.
		Million metric tonne of CO_2-eq	GHG emissions from fuel combustion	Annual/ national scale	2010 -2015	United Nations Industrial Development Organization (UNIDO) (https://www.unido.org) UNIDO Industrial Statistics Database System (INDSTAT) (https://stat.unido.org/)	To quantify greenhouse gas (GHG) emissions from energy use within the national annually.
1.5	Land use	Million hectare/ raster	It deals with the resolution is 300×300 m.	Annual/ national scale	1992-2015	European Space Agency (http://maps.elie.ucl.ac.be/CCI/viewer/download.php)	Total land use is measured by calculating the amount of biologically productive land of each country, which is comprised of agriculture, forest, and built-up area.
	Land productivity	Thousand $ per hectare	It deals with the land area of country and GDP of a nation .	Annual/national scale	1992-2015	World Bank (https://data.worldbank.org/)	Land productivity is the measure of the ratio of nation's total GDP ($) to the total land area of a country.
	Land use by major sector (Agriculture)	Million hectare	It deals with the land occupied by the agriculture sector only.	Annual/national scale	1992-2015	European Space Agency (http://maps.elie.ucl.ac.be/CCI/viewer/download.php)	The purpose of this indicator is to measure the area of land occupied by the agriculture sector .
1.6	Agricultural productivity	kg/hectare	Cereal yield		2010 -2018	FAO (http://www.fao.org/)	This indicator presents production data on

No.	Data inventory Items	Unit/ Format	Description	Scale	Time series	Methodology/ Data Sources	Purpose of regional indicator
						FAOSTAT Agriculture database (http://faostat3.fao.org/home/E)	cereals crops harvested for dry grain only within the national
		Billion US dollars	Agriculture value added per worker	Annual/ national scale	2010 -2019	World Bank (http://www.worldbank.org; http://data.worldbank.org/data-catalog/world-development-indicators)	This indicator gives a measure of the value added which is the net output of a sector after adding up all outputs and subtracting intermediate inputs
		Million US dollars	Value of agricultural production	Annual/national scale	2010 -2018	FAO (http://www.fao.org/) FAOSTAT Agriculture database (http://faostat3.fao.org/home/E)	This indicator gives a measure of the value of agricultural production in constant terms as derived using the average prices of a selected year.
1.7	Waste management	Tonne	Municipal waste collected	Annual/national scale	2010 -2019	National Statistical Systems (NSS), UNSD's environment statistics database (https://unstats.un.org/unsd/envstats/qindicators and https://unstats.un.org/unsd/envstats/country_files)	To quantify municipal waste that is collected within the country annually
		Tonne	Municipal waste generated	Annual/national scale	2010 -2019	NSS, UNSD's environment statistics database (https://unstats.un.org/unsd/envstats/qindicators and	To quantify municipal waste that is generated within the country annually

No.	Data inventory Items	Unit/ Format	Description	Scale	Time series	Methodology/ Data Sources	Purpose of regional indicator
						https://unstats.un.org/unsd/envstats/country_files)	
		Tonne	Municipal waste recycled	Annual/national scale	2010 -2019	NSS, UNSD's environment statistics database (https://unstats.un.org/unsd/envstats/qindicators and https://unstats.un.org/unsd/envstats/country_files)	To quantify municipal waste that is recycled within the country annually
		Percentage (%)	Municipal Solid Waste collection coverage by cities	Annual/national scale	2010 -2018	UNSD's environment statistics database (https://unstats.un.org/unsd/envstats/qindicators and https://unstats.un.org/unsd/envstats/country_files)	This indicator gives the percentage of waste coverages in cities within the region
		Tonne	Hazardous waste incinerated	Annual/national scale	2010 -2017	NSS, UNSD's environment statistics database (https://unstats.un.org/unsd/envstats/qindicators and https://unstats.un.org/unsd/envstats/country_files)	To quantify hazardous waste incinerated within the country annually
		Tonne	Hazardous waste generated	Annual/national scale	2010 -2019	NSS, UNSD's environment statistics database (https://unstats.un.org/unsd/envstats/qindicators and https://unstats.un.org/unsd/envstats/country_files)	To quantify hazardous waste generated within the country annually
2	**Trade dependency**						

No.	Data inventory Items	Unit/ Format	Description	Scale	Time series	Methodology/ Data Sources	Purpose of regional indicator
2.1	Physical Trade Balance (PTB)	Tonne; tonne per capita	A measure of the physical trade surplus or deficit in the economy, which equals imports minus exports .	Annual/national scale	2010-2017	Commonwealth Scientific and Industrial Research Organisation (CSIRO) (https://materialflows.csiro.au/forms/form-mf-start-world.aspx)	To provide information on whether a country depends on resources from abroad (positive PTB; a net importer) or supplies physical goods to the world market (negative PTB; a net exporter).
2.2	Unit price of trade	$ per kg	It measures the countries' receiving (paying) for each unit mass of exports (imports).	Annual/national scale	2010-2017	CSIRO (https://materialflows.csiro.au/forms/form-mf-start-world.aspx) WTO (https://stats.wto.org/)	To report the relationship between how much money a country pays for its imports and how much it receives from its exports.
3	**Resource efficiency**						
3.1	Material Intensity of the economy	kg/$	The amount of material (in kg) used to produce one unit of GDP (in $)	Annual/national scale	2010-2017	United Nations Environment Programme International Resource Panel Global Material Flows Database (https://www.resourcepanel.org/global-material-flows-database)	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

No.	Data inventory Items	Unit/ Format	Description	Scale	Time series	Methodology/ Data Sources	Purpose of regional indicator
							economic and social gains that can be obtained from resource use.
3.2	Energy intensity of the economy	toe/ thousand 2015 USD	The overall energy intensity of an economy refers to the amount of energy used to produce goods and services measured in terms of GDP .	Regional comparison	1990-2018	IEA (https://www.iea.org/data-and-statistics)	This indicator often used to analyze the energy efficiency of a specific nation .In general, the ratio of energy use to GDP is used to assess how well the economy is utilizing its energy in terms of monetary output.
		toe/ thousand 2015 USD		Country-wise comparison	2010, 2015, and 2018.	IEA (https://www.iea.org/data-and-statistics)	
4 Resource use in major sectors							
41.	Emissions of the energy sector	Mt of CO_2-eq	Direct GHG emissions that are produced in the generation and transmission of energy are a relevant indicator of both the carbon efficiency with which energy services are provided, and the scale of the energy needs of a society .	Regional comparison	1990-2018	IEA (https://www.iea.org/data-and-statistics)	This indicator looks at the environmental impacts by the energy sector from the climate change perspective.
		tonne of CO_2 equivalent /toe		Country-wise comparison	2010, 2015, and 2018	IEA (https://www.iea.org/data-and-statistics)	
5 Consumption-based indicators for natural resource use							

No.	Data inventory Items	Unit/ Format	Description	Scale	Time series	Methodology/ Data Sources	Purpose of regional indicator
5.1	Material Footprint	Tonne, tonne/capita	The actual primary material demand total (tonne) and per capita (tonne/capita) of any economy	Annual/national scale	2010-2017	United Nations Environment Programme International Resource Panel Global Material Flows Database (https://www.resourcepanel.org/global-material-flows-database)	Material footprint of consumption is an attribute of global material extraction to final demand including the final consumption of households, governments, and capital investment .The indicator provides information about the actual primary material demand of any economy without including the extraterritorial trade intervention .Also, the indicator reports the actual quantity of primary materials consumption and the capital investment a country relies upon independently from where the material extraction has occurred in the global economy .
5.2	Water Footprint	Billion cubic meters	It deals with overall water use in all kind of activities by the inhabitants of the country.	Annual/national scale	2010-2015	Eora global (https://www.worldmrio.com/countrywise/)	The water footprint of a country is the total volume of water used, directly or indirectly, to produce the goods and

No.	Data inventory Items	Unit/ Format	Description	Scale	Time series	Methodology/ Data Sources	Purpose of regional indicator
							services consumed by the inhabitants of the country.
6	**Resources and human development**						
6.1	Human Development Index (HDI)	Unitless	A measure of human development in any economy	none	2010-2017	United Nations Development Programme (http://hdr.undp.org/en/data)	The Human Development Index (HDI) is a measure of human development. HDI consists of three different domains, viz., literacy rate, life expectancy, and standard of living. It can be calculated by taking weighted average of literacy rate, life expectancy ratio, and GNI per capita.
6.2	Economic Growth (GDP)	$	A measure of economic growth ($)	Annual/national scale	2010-2017	World Bank (https://data.worldbank.org/)	Gross domestic product (GDP) is the most commonly used indicator for measuring economic growth. 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 broad estimate of overall domestic production of any region.

No.	Data inventory Items	Unit/ Format	Description	Scale	Time series	Methodology/ Data Sources	Purpose of regional indicator
6.3	Investment and consumption	Percentage of GDP	Foreign direct investment refers to direct investment equity flows in the reporting economy .It is the sum of equity capital, reinvestment of earnings, and other capital .	Country-wise comparison	1990-2019	World Bank (https://data.worldbank.org/)	Direct investment is a category of cross-border investment associated with a resident in one economy.
6.4	Debt, inflation	Percentage of GDP	The general government gross debt indicates the overall accrued external financial obligations which are accumulated to finance expenditures above the generated revenues .	Country-wise comparison	2010, 2015, and 2018.	International Monetary Fund (IMF) (https://www.imf.org/external/datamapper/GGXWDG_NGDP@WEO/OEMDC/ADVEC/WEOWORLD)	To analyze the economic performance of nations in the Asia Pacific region.
		Annual percentage change in average consumer prices	Inflation is the rise of the price level in an economy over a specific time period .The rise in general prices causes the currency unit to be able to buy lesser goods and services thus reflecting the reduction in the purchasing power .	Country-wise comparison	2010, 2015, and 2018.	IMF (https://www.imf.org/external/datamapper/PCPIPCH@WEO/WEOWORLD/VEN/IRN)	To analyze the economic performance of selected nations in Asia Pacific region.
6.5	Access to energy	%of population	It deals with overall percentage of population)rural and urban (that have access to electricity.	Annual/national scale	2000-2019	World Bank (https://data.worldbank.org/)	This indicator is measured as the percentage of people with access to electricity.
	Water access	%of population	It deals with overall percentage of population)rural and urban (that have access to drinking water.	Annual/national scale	2000-2020	WHO/UNICEF Joint Monitoring Programme (https://washdata.org/)	It is measured as the percentage of people with access to drinking water services .

No.	Data inventory Items	Unit/ Format	Description	Scale	Time series	Methodology/ Data Sources	Purpose of regional indicator
	Sanitation access	%of population	It deals with overall percentage of population)rural and urban (that have access to sanitation.	Annual/national scale	2000-2020	Global SDG Indicators Database (https://unstats.un.org/sdgs/indicators/database/?indicator=15.4.2)	It is measured as the percentage of people with access to sanitation services .
7	**Inclusive green recovery**						
7.1	COVID spending	Percent of 2020 GDP	It summarizes the key fiscal measures taken by governments in response to the COVID-19 pandemic since January 2020 .The database categorizes different types of fiscal support)i.e., equity, loans, and guarantees, and additional spending/forgone revenues (while focusing the discretionary measures that supplement existing automatic stabilizers.	Country-wise comparison	2020 to onward	IMF (https://www.imf.org/en/Topics/imf-and-covid19/Fiscal-Policies-Database-in-Response-to-COVID-19)	To analyze the fiscal measure taken by the selected economies in the Asia Pacific region.
7.2	Natural capital	Constant 2014 USD per capita	The indicator includes the valuation of fossil fuel energy)oil, gas, hard and soft coal (and minerals)bauxite, copper, gold, iron ore, lead, nickel, phosphate, silver, tin, and zinc(, agricultural land)cropland and pastureland(, forests)timber and some nontimber forest products(, and protected areas .Values	Country-wise comparison	2005, 2010, and 2014.	World Bank (https://databank.worldbank.org/source/wealth-accounts/Type/TABLE/preview/on#)	Gross Domestic Product)GDP (looks at only one part of economic performance—income—but says nothing about wealth and assets that underlie this income .For example, when a country exploits its minerals, it is depleting wealth . However, natural capital

No.	Data inventory Items	Unit/ Format	Description	Scale	Time series	Methodology/ Data Sources	Purpose of regional indicator
			are measured at market exchange rates in constant 2014 US dollars, using a country-specific GDP deflator .				is the valuation of natural resources of any economy.
7.3	Green spending	USD per capita	Green spending could help the region to address the recession due to pandemic, reduce carbon emissions, and transition to a strong and resilient long-term growth pathway .	Country-wise comparison	January 2020–present	Oxford University Economic Recovery Project (OUERP) (https://recovery.smithschool.ox.ac.uk/tracking/)	The spending's data for the Asia pacific region is retrieved from the Global Recovery Observatory which tracks and assesses every individual COVID-19 related fiscal spending policy announced by the leading economies worldwide for potential impacts on the environment and the socio-economy .
7.4	Green energy investments	Percentage (%)	Green energy investments specifies the motivation towards green initiative taken by the nations which also plays a crucial role in economy-wide decarbonization .	Country-wise comparison	2005-2019	Asian Development Bank (ADB) (https://www.adb.org/publications/financing-clean-energy-developing-asia)	To analyse the green initiatives taken by the selected economies in the Asia Pacific region.
7.5	Green Transport	TWh	The indicator selected to assess the electromobility in the Asia Pacific region is 'Electricity demand from the global EV-fleet by country or region-2030' and measured in terms of TWh.	Country-wise comparison	2030	IEA (https://www.iea.org/data-and-statistics/charts/electricity-demand-from-the-global-ev-fleet-by-country-region-2030)	Two indicators were selected to analyze the status que of the transport sector in green perspective :electricity demand from the global EV-fleet and biofuel

No.	Data inventory Items	Unit/ Format	Description	Scale	Time series	Methodology/ Data Sources	Purpose of regional indicator
		Mtoe	Another indicator selected to assess the green transport status in the region is 'Biofuel production in 2019 compared to consumption in 2030 under the sustainable development scenario'.	Country-wise comparison	2019 & 2030	IEA (https://www.iea.org/data-and-statistics/charts/biofuel-production-in-2019-compared-to-consumption-in-2030-under-the-sustainable-development-scenario)	production in 2019 compared to consumption in 2030 under the sustainable development scenario .
7.6	Green research and development	Constant 2019 USD	Green research and development or green R&D mainly puts a focus on R&D investment and activities for eco-innovation and eco-friendly products .This could lead to improve productivity and efficiency on materials and resources use as well as less pollutants being emitted.	Country-wise comparison	Average 2010-2020	ADB (https://kidb.adb.org/themes/sustainable-development-goals/sdg-17-partnership-for-the-goals)	The indicator (i.e., Dollar value of financial and technical assistance committed to developing economies) is the selected to assess the green research and development in the Asia Pacific region.

Appendix II

Metadata

Regional indicators and database on resource efficiency In the Asia Pacific

1 Natural resources

Materials, energy, water and land are considered as main resource uses, thus emissions, impacts and waste related to these resource uses are taken into consideration. As agricultural sector is a key significant sector in the Asia Pacific region, so that a focus is placed on the productivity of this sector. With regards to emissions, impacts and waste, greenhouse gas emissions and waste management are selected to represent those aspects. Hence, material use, energy use, water use, land use, agricultural productivity, greenhouse gas emissions, and waste management are selected as regional resource efficiency indicators by means of natural resources.

1.1 Material use

a. Indicator description

Consumption and production are essential to economic activities, but they can also contribute to the depletion of natural capital if they are not handled properly. Therefore, out of the 17 United Nations Sustainable Development Goals (SDGs), SDG 12 titled "responsible consumption and production is directly dedicated to ensuring sustainable consumption and production. The main idea of this goal is to encourage sustainable consumption and production by reducing natural resource exploitation, reducing the use of harmful materials, and relying on production practices that produce less pollution and generate less waste. To increase efficiency in consumption and production is also related to the target of SDG 8.4 (improving resource efficiency in consumption and production) and it encompasses the majority of material-related metrics. Besides, targets of SDG 12.2 and SDG 8.4 are measured by the same indicators. Material footprint, material footprint per capita, and material footprint per GDP are mentioned as indictor 8.4.1 and indicator 12.2.1. Domestic material consumption, domestic material consumption per capita, and domestic material consumption per GDP are the same for indictors SDG 8.4.2 and indicator 12.2.2.

To accomplish the sustainable development goals based on sustainable consumption and production, as well as efficient management of natural resources and ecosystems, The Asia Pacific region has begun a new route of economic development and has become the largest user of natural resources as well as the biggest producer in the world[3]. In this section, the total domestic material consumption (DMC) - the annual quantity of raw materials extracted from the domestic territory including all physical imports and excluding all physical exports[4] – (tonnes) and domestic material consumption per capita (DMC per capita, tonnes per capita) are used as indicators to measure the material use in the Asia Pacific developing countries.

The total domestic material consumption (DMC, tonne) and domestic material consumption per capita (tonne per capita) are used as indicators to measure the material use.

b. Unit of measure

Tonne, tonne/capita

c. Methodology

The IRP Global Material Flows and Resource Productivity working group compiles the data from countries and from other sources. It is calculated as direct imports (IM) of material plus domestic extraction (DE) of materials minus direct exports (EX) of materials measured in metric tonnes. DMC measure the number of materials that are used in economic processes. It does not include materials that are mobilized the process of domestic extraction but do not enter the economic process. DMC is based on official economic statistics, and it requires some modelling to adapt the source data to the methodological requirements of the MFA. The accounting standard and accounting methods are set out in the EUROSTAT guidebooks for MFA accounts in the latest edition of 2013. MFA accounting is also part of the central framework of the System of integrated Environmental-Economic Accounts (SEEA). The data related to DMC was obtained for 18 Asia Pacific developing countries and 6 developed countries for the time series 2010 to 2017. The data was obtained from World Environment Situation Room.

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- Data license

The data for total domestic material consumption (DMC, tonnes) and domestic material consumption per capita (DMC per capita, tonnes per capita) is free to access and use.

- Data source

[3] 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.

[4] https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Domestic_material_consumption_(DMC)

The global material flows database is based on country material flow accounts from the European Union and Japan and estimated data for the rest of the world. Estimated data is produced on the bases of data available from different national or international datasets in the domain of agriculture, forestry, fisheries, mining, and energy statistics. International statistical sources for DMC and MF include the IEA, USGS, FAO and COMTRADE databases.

The data was obtained from the United Nations Environment Programme International Resource Panel Global Material Flows Database (https://www.resourcepanel.org/global-material-flows-database). The available data is ready to use and very easy to access. Moreover, the data is publicly available.

e. References

UN Environment Programme. 2021. United Nations Environment Programme International Resource Panel Global Material Flows Database. The International Resource Panel. Available at: https://www.resourcepanel.org/global-material-flows-database.

1.2 Renewable energy use

a. Indicator description

The renewable energy use is measured with the indicator renewable energy share in total final consumption; which is the percentage of final consumption of energy that is derived from renewable resources. Renewable energy consumption includes consumption of energy derived from hydro, wind, solar, solid biofuels, liquid biofuels, biogas, geothermal, marine and renewable waste. Total final energy consumption is calculated as total final consumption minus non-energy use. Furthermore, the specific renewable energy sources are: solar energy (e.g., solar PV and solar thermal); liquid biofuels (e.g., bio-gasoline, biodiesels, and other liquid biofuels); solid biofuels (e.g., fuelwood, animal waste, vegetable waste, black liquor, bagasse, and charcoal).

The indicator is used to analyze the situation of the Asia Pacific region towards renewable energy use (in terms of percentage of final consumption of energy which is derived from renewable resources).

b. Unit of measure

The renewable energy share in the total final energy consumption is measured in terms of percentage.

c. Methodology

The data for indicator 'the renewable energy share in the total final energy consumption, % (SDG 7.2.1)' was retrieved form the UNEP databank under the "Energy", "Energy use and efficiency".

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1.3 Water use

In terms of quantity, water is the largest resource used in economic production, which is more than three quarters. As industrial progress is linked with GDP growth, that puts further pressure on water resources even after the decoupling efforts (UNEP, 2015). It can be summarized that the agriculture sector is the main water user followed by the domestic and industrial sectors which share an equal rank. Secondly, the deprivation of freshwater may damage human health, ecosystem quality, and freshwater resources (Pfister et al., 2009).

a. Indicator description

Water use (water withdrawal) indicator presented here reports total freshwater abstractions for use in agriculture, industry, and in the residential sector, from all surface and underground sources. Direct rainfall on crops is not included. Agricultural water withdrawal measures the water withdrawal for the agriculture sector only from ground and surface water resources and soil moisture is not included.

The water withdrawals deal with the measure of total annual water withdrawal by the agriculture, industry, and domestic sectors. While, the purpose of Agricultural water withdrawal is to give a measure of the annual water withdrawal for the agriculture sector.

b. Unit of measure

Billion cubic meters

c. Methodology

It is considered the total freshwater abstractions for use in agriculture, industry, and in the residential sector, excluding the green water.

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Pfister, S., Koehler, A., & Hellweg, S. (2009). Assessing the Environmental Impacts of Freshwater Consumption in LCA. *Environmental Science & Technology, 43*(11), 4098–4104. https://doi.org/10.1021/es802423e

1.4 Total Land use

a. Indicator description

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 (Roser, 2014; Winkler et al., 2021). More than 50% of Asian land area is under agriculture. Agricultural expansion is the most pervasive anthropogenic land conversion process in Asia. The total area of agricultural land in South and Southeast Asia has increased by 296 and 1275%, respectively from 1700 to 1980 (Meyer, 1996). This expansion is driven by growth in population, GDP, and food requirements. Asia is home to many of the world's tropical rain forests and subtropical mountain forests. From 1850 to 1978, about 1.2 million km^2 of the forest area was cleared in Asia (Zhao et al., 2006). According to an assessment conducted in 2005, the forests of the Asia Pacific cover around 26 % of the land area in the region (FAO, 2005). Southeast Asia has the highest deforestation rate of any major tropical region. Large-scale deforestation has occurred in Asia, primarily as a result of agricultural expansion and timber harvest.

The Asia Pacific region is home to 60% of the world's population and contains the highest concentration of megacities in the world. Of the world's 35 megacities in 2017, 21 were located in Asia Pacific, (UNDRR, 2020). The conversion of agricultural land to urban land has been most pronounced. Urbanization has also caused increased summer temperatures, nighttime temperatures, and water quality deterioration (Zhao et al., 2006). Overall, changes in land use land cover (LULC) can trigger changes in multidimensional issues (Winkler et al., 2021). In short, agriculture, forestry, and urban land areas are the major landholding sectors in the Asia Pacific region. Forest cover is changing into agricultural land, and agricultural land is converted into an urban area.

b. Unit of measure

Million hectare

c. Methodology

The biologically productive land in each country, which includes agriculture, forest, and built-up land, is used to calculate total land use of the country. Total land use (agriculture, forest, and built-up area sectors) was generated after downloading from European Space Agency. Extracted from: (http://maps.elie.ucl.ac.be/CCI/viewer/download.php) and processing the global land use maps in Arc GIS 10.2.2. The land use under agriculture, forest, and built- up area was separated under the guidelines of European Space Agency given at http://maps.elie.ucl.ac.be/CCI/viewer/download/ESACCI-LC-Ph2-PUGv2_2.0.pdf.

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Zhao, S., Peng, C., Jiang, H., Tian, D., Lei, X., & Zhou, X. (2006). Land use change in Asia and the ecological consequences. *Ecological Research, 21*(6), 890–896. https://doi.org/10.1007/s11284-006-0048-2

1.4.1 Total Land Use

a. Indicator description

The total land use is measured by calculating the amount of biologically productive land of each country, which is comprised of agriculture, forest, and built-up area. These land use classes (agriculture, forest, and built-up area) are mainly responsible for resource consumption and production. The remaining area of each country is classified as “Others”. The “Others” land use class was not included in the total land use because this land use class is very less productive or not productive. It consists of bare land, snow area, water bodies, grassland, and shrubland area.

b. Unit of measure

Million hectare/raster

c. Methodology

The biologically productive land in each country, which includes agriculture, forest, and built-up land, is used to calculate total land use of the country. Total land use (agriculture, forest, and built-up area sectors) was generated after downloading from European Space Agency. Extracted from: (http://maps.elie.ucl.ac.be/CCI/viewer/download.php) and processing the global land use maps in Arc GIS 10.2.2.

The land use under agriculture, forest, and built- up area was separated under the guidelines of European Space Agency given at http://maps.elie.ucl.ac.be/CCI/viewer/download/ESACCI-LC-Ph2-PUGv2_2.0.pdf.

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  Land use land cover data was downloaded from European Space Agency (http://maps.elie.ucl.ac.be/CCI/viewer/download.php).

- Data source

European Space Agency. Extracted from: (http://maps.elie.ucl.ac.be/CCI/viewer/download.php) Data of Access: [14-03-2022].

e. References

Global Footprint Network (2019). Earth Overshoot Day 2019 is July 29th, the earliest ever. Available at: https://www.footprintnetwork.org/2019/06/26/press-release-june-2019-earth-overshoot-day/

1.4.2 Land use per capita

a. Indicator description

The land use per capita is a nation's total land use (agriculture, forest, and built-up area) divided by the total population of the nation.

b. Unit of measure

hectare /capita

c. Methodology

For the indicator “land use per capita ", total land use (agriculture, forest, and built- up area sectors) was generated after downloading from European Space Agency. Extracted from: (http://maps.elie.ucl.ac.be/CCI/viewer/download.php) and processing the global land use maps in Arc GIS 10.2.2.

The land use under agriculture, forest, and built- up area was separated under the guidelines of European Space Agency given at http://maps.elie.ucl.ac.be/CCI/viewer/download/ESACCI-LC-Ph2-PUGv2_2.0.pdf. Then the total land use of a country was divided by its population to get the land use per capita.

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- Data source

The population data was obtained from World bank data site. Extracted from: [https://data.worldbank.org/indicator/AG.SRF.TOTL.K2?locations=AF].

e. References

European Space Agency. The Land Cover CCI Climate Research Data Package. Available at: http://maps.elie.ucl.ac.be/CCI/viewer/download.php.

World Bank. (2020). Surface area (sq. km) - Afghanistan [Data set]. World Development Indicators. https://data.worldbank.org/indicator/AG.SRF.TOTL.K2?locations=AF

1.4.3 Land productivity

a. Indicator description

Land productivity is the measure of the nation's total GDP ($) divided by total land area of a country.

b. Unit of measure

Dollar per hectare

c. Methodology

Land productivity of a country is obtained by divided the total GDP of the country to the total land area of the country. The GDP and total land area of the country was taken from World Bank data site.

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- Data source

World Bank (2022). Extracted from: [https://data.worldbank.org/indicator/AG.SRF.TOTL.K2?locations=AF]. Data of Access: [14-03-2022].

e. References

World Bank. (2020). Surface area (sq. km) - Afghanistan [Data set]. World Development Indicators. https://data.worldbank.org/indicator/AG.SRF.TOTL.K2?locations=AF

1.4.4 Land use by Agriculture sector

a. Indicator description

Land use by major sector is considered by the land use occupied by the agriculture sector.

b. Unit of measure

Million hectare

c. Methodology

For the indicator “land use by major sector", land use under agriculture sector was generated after downloading from European Space Agency. Extracted from:

(http://maps.elie.ucl.ac.be/CCI/viewer/download.php) and processing the global land use maps in Arc GIS 10.2.2. The land use under agriculture was separated under the guidelines of European Space Agency given at http://maps.elie.ucl.ac.be/CCI/viewer/download/ESACCI-LC-Ph2-PUGv2_2.0.pdf

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European Space Agency. The Land Cover CCI Climate Research Data Package. Available at: http://maps.elie.ucl.ac.be/CCI/viewer/download.php.

1.5 Agricultural productivity

a. Indicator description

Agricultural productivity has a prominent role to play in the economic and social agenda of developing countries. There has been a focus on increasing agricultural productivity in many regions such as Africa, Asia, and Europe to achieve agriculture-led growth and fulfil the targets on food and nutrition security. Thus, increased agricultural productivity is a key factor for achieving national goals of food security, rural poverty alleviation, as well as overall economic growth. For many countries within the Asia Pacific region, agriculture contributes significantly to both urban and rural livelihoods, trade income, and food security. Agricultural productivity represents the efficiency of the production process; it has been widely used as output per hectare (i.e., land productivity) and output per person (i.e., labor productivity).

The agricultural sector is employed by many countries around the world to achieve food security and to improve their economy through export. Its productivity is related to several of the Sustainable Development Goal indicators (particularly SDG 2).

b. Unit of measure

kg/hectare

c. Methodology

Cereal yield Harvested production per unit of harvested area for crop products. In most of the cases yield data are not recorded but obtained by dividing the production data by the data on area harvested. Data on yields of permanent crops are not as reliable as those for temporary crops either because most of the area information may correspond to planted area, as for grapes, or because of the scarcity and unreliability of the area figures reported by some countries. (Source: FAO, Statistics Division (FAOSTAT) and Owner: FAO)

Value of agricultural production

The total value of Annual agricultural production, as estimated by FAO and published by FAOSTAT in International Dollars (I$). It provides a cross country comparable measure of the relative economic size of the food production sector in the country. The indicator is calculated on 3-year averages. The value of agricultural production has been derived by multiplying net production (i.e., gross production after deductions of quantities used as seed and feed) with international commodity average prices. These "international prices", expressed in so-called "international dollars", are derived using a Geary-Khamis formula for the agricultural sector. This method assigns a single "price" to each commodity. For example, one metric ton of wheat has the same price regardless of the country where it was produced. (Source: FAO, Statistics Division, Owner: FAO)

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- Data source

Crop statistics are recorded for 173 products, covering the following categories: Crops Primary, Fibre Crops Primary, Cereals, Coarse Grain, Citrus Fruit, Fruit, Jute-like Fibres, Oilcakes Equivalent, Oil crops Primary, Pulses, Roots and Tubers, Treenuts and Vegetables and Melons. Data are expressed in terms of area harvested, production quantity and yield. The objective is to comprehensively cover production of all primary crops for all countries and regions in the world. The source of data available at given link i.e., FAOSTAT Agriculture database (http://faostat3.fao.org/home/E.).

e. References

FAOSTAT. (2021). Value of Agricultural Production. Available at:
https://www.fao.org/faostat/en/#data/QV/metadata

1.6 Greenhouse gas emissions (GHG)

a. Indicator description

As the main cause of climate change has been identified as the emission of GHGs connected to human activities, it is imperative to draw up a scheme to measure and keep these emissions in check (within sustainable limits). These ideas were reinforced by the Paris agreement which involves both industrialized and developing countries with market economies and aims to reduce GHG emissions on a global scale (UNFCCC, 2016). The total GHG emissions indicator, expressed in million metric tonnes of CO_2 equivalent, is composed of all GHG emissions excluding short-cycle biomass burning (such as agricultural waste burning and Savannah burning) but including other biomass burning (such as forest fires, post-burn decay, peat fires and decay of drained peatlands), all anthropogenic CH_4 emissions, N_2O emissions, F-gases (HFCs, PFCs, and SF_6), and CO_2 emissions of drained peatlands). The purpose of this indicator is to give a summation measure of all GHG emissions.

b. Unit of measure

Million metric tonne of CO_2 equivalent

c. Methodology

The general principles of EDGAR such as emissions calculation per source categories with a generic approach consistently applied for all world countries and with geographic distribution to the place of emission. This includes consistent set of activity data for calculating various substances, greenhouse gases and air pollutants, important for UNFCCC and the co-benefits of air quality and climate policies.

GHG from Agriculture: All GHG agricultural sectors, total emissions in CO2eq (gigagrams) Agriculture Total contains all the emissions produced in the different agricultural emissions sub-domains, providing a picture of the contribution to the total amount of GHG emissions from agriculture. GHG Emissions from agriculture consist of non-CO2 gases, namely methane (CH4) and nitrous oxide (N2O), produced by crop and livestock production and management activities. [Source: FAO, Statistics Division (FAOSTAT) and Owner: FAO]

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- Data license

License; Conditions of emission data use and code of conduct

Users of the data are obliged to acknowledge the source of the data with a reference to the EDGARv5.0 website (link) to Crippa et al. (2019) and to the DOI link: (https://data.jrc.ec.europa.eu/collection/EDGAR).

Co-authorship and involvement of the EDGAR Team in the emission data analysis is highly appreciated. User's comments and requests can be sent via email to the authors (jrc-edgar@ec.europa.eu).

- Data source

EDGARv6.0 provides emissions of the three main greenhouse gases (CO_2, CH_4, N_2O). Input to EDGAR are international annual statistics, that are collected from 1970 onwards till year t-1 for CO2 and with 2 or even 4 years delay for other greenhouse gases respectively air pollutants and particulate matter. The source of data available at given link:

European Commission, Joint Research Centre (EC-JRC)/Netherlands Environmental Assessment Agency (PBL). Emissions Database for Global Atmospheric Research (EDGAR), release EDGAR v5.0 (1970 - 2017) of November 2019 (http://edgar.jrc.ec.europa.eu/)

e. References

Crippa, Monica; Guizzardi, Diego; Muntean, Marilena; Schaaf, Edwin; Lo Vullo, Eleonora; Solazzo, Efisio; Monforti-Ferrario, Fabio; Olivier, Jos; Vignati, Elisabetta (2021): EDGAR v6.0 Greenhouse Gas Emissions. European Commission, Joint Research Centre (JRC) [Dataset] PID: http://data.europa.eu/89h/97a67d67-c62e-4826-b873-9d972c4f670b

UNFCCC (2016). The Paris Agreement .United Nations Framework Convention on Climate Change. United Nations Climate Change. Available at :https//:unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement

https://edgar.jrc.ec.europa.eu/methodology

1.7 Waste management

a. Indicator description

It is imperative to state the kinds of waste materials generated in societies. These wastes are of several types which include municipal (household, commercial, and demolition waste), biomedical, and electronic (e-waste) waste. The enormous waste being generated nowadays can be attributed to the continual increase in population and urbanization; this increment has been at an unprecedented rate. Also, technological innovations in the electronic industry are usually very fast, resulting in rapid redundancy and a decreasing lifetime of products. In Asia, an estimated 1.2 billion tonnes of municipal solid waste was generated in 2016; this figure is anticipated to increase to 1.5 billion tonnes by 2030, and 1.9 billion tonnes by 2050 (World Bank, 2018). All these culminate in causing waste management problems. To solve these problems, effective waste management schemes need to be implemented. Waste management schemes should include the collection and proper disposal of this waste. Efficient and effective solid waste management schemes are critical for achieving sustainable development as well as sustainable consumption and production in various countries.

To quantify municipal waste that is collected, generated, and recycled within the country annually. While, Municipal Solid Waste collection coverage by cities gives the percentage of waste coverages in cities within the region. As well as, to quantify hazardous waste incinerated and generated within the country annually.

b. Unit of measure

- Municipal waste collected (Tonne)
- Municipal waste generated (Tonne)
- Municipal waste recycled (Tonne)
- Municipal Solid Waste collection coverage by cities (Percentage (%))
- Hazardous waste incinerated (Tonne)
- Hazardous waste generated (Tonne)

c. Methodology

The data for all the waste management sub-sections in this report are collected by the means of questionnaires and are compiled by different institutions in a country. The national statistical offices or ministries of environment are asked to bring together the data from these different sources. The biennial data collection is a joint activity of the United Nations Statistics Division (UNSD) and the United Nations Environment Programme contributes to the development of the UNSD International Environment Statistics Database. The data is analyzed and consolidated by UNSD for use in international work and made available to users at UNSD's website.

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- Data source

In many countries there are no comprehensive data or estimates of the total amounts of waste generated by the different human/economic activities. Instead, they focus on certain types of waste or waste materials that are of high priority for waste management. In some countries, waste statistics are only available at the sub-national (regional, provincial, state) or city level. If there are no data at the national level, a report of the sub-national or city level data is given and a footnote indicating the coverage of the data is provided. The source of data available at given link:

- Municipal waste collected:
  UNSD's environment statistics database
  (https://unstats.un.org/unsd/envstats/qindicators and
  https://unstats.un.org/unsd/envstats/country_files)
- Municipal waste generated
  UNSD's environment statistics database
  (https://unstats.un.org/unsd/envstats/qindicators and
  https://unstats.un.org/unsd/envstats/country_files)
- Hazardous waste incinerated
  UNSD's environment statistics database
  (https://unstats.un.org/unsd/envstats/qindicators and
  https://unstats.un.org/unsd/envstats/country_files)

e. References

DESA (2019). United Nations National Quality Assurance Frameworks Manual for Official Statistics Including recommendations, the framework and implementation guidance. Available at: https://unstats.un.org/unsd/methodology/dataquality/un-nqaf-manual/

UNSD (2020). Environment Statistics Database. Statistics Division United Nations, New York. Available at: https://unstats.un.org/unsd/envstats/qindicators.

UNSD (2020). Environment Statistics Database. Statistics Division United Nations, New York. Available at: https://unstats.un.org/unsd/envstats/country_files

World Bank. (2018). What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050. Washington, DC: World Bank. Available at: https://openknowledge.worldbank.org/handle/10986/30317

2 Resource efficiency

2.1 Material Intensity of the economy

a. Indicator description

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. The Asia Pacific developing countries are continuing to industrialize which causes the demand of primary materials to further escalate in these countries. The efficient use of materials can aid these to attain a more competitive and environmentally sustainable development route. In this report, the material intensity indicator is defined as the domestic material consumption per unit of gross domestic product (DMC per GDP).

b. Unit of measure

kg per $ (annual USD)

c. Methodology

The material intensity indicator is defined as the domestic material consumption per unit of gross domestic product (DMC per GDP). The data for DMC (tonnes) and GDP ($) was collected for 18 Asia Pacific developing countries and 6 developed countries for the time series 2010 to 2017. Material intensity (MI) was calculated by dividing yearly DMC on gross domestic product (GDP) of the corresponding year for all the concerned countries. The mathematical approach to calculate material intensity is presented in Equation 1.

$$MI = \frac{DMC\ (kg)}{GDP\ (\$)} \qquad \text{(Eq 1)}$$

Where, DMC is annual domestic material consumption, GDP is gross domestic product and is the corresponding year for which material intensity is being calculated. The data for DMC was obtained from the World Environment Situation Room, while the data for GDP was obtained from the World Bank databank. The obtained data is presented in the form of bar charts to assess and compare situation of the MI in all concerned countries from various angles.

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- Data source

The global material flows database is based on country material flow accounts from the European Union and Japan and estimated data for the rest of the world. Estimated data is produced on the bases of data available from different national or international datasets in the domain of agriculture, forestry, fisheries, mining, and energy statistics. International statistical sources for DMC and MF include the IEA, USGS, FAO and COMTRADE databases.

"Human Development Data Center" (http://hdr.undp.org/en/data (March 3, 2022))

"World Development Indicators" (https://databank.worldbank.org/source/world-development-indicators March 3, 2022))

e. References

The World Bank Databank. 2022. World Development Indicators. The World Bank. Available at: https://databank.worldbank.org/home.aspx.

United Nations Development Programme 2020. Human Development Data Center. Available at: http://hdr.undp.org/en/data.

2.2 Energy intensity of the economy

a. Indicator description

The overall energy intensity of an economy refers to the amount of energy in tonnes of oil equivalent (toe) that is used for producing goods and services measured in terms of GDP (in thousand 2015 USD) which is related to the efficiency of energy use. The energy economy of the region is continuously improving. Using energy more efficiently reduces costs and is an important factor in achieving a low carbon development path. In the Asia Pacific region, it is expected that the energy use will continue to grow over the next couple of decades due to the use of energy-efficient technologies in the building, transport, heavy industry and manufacturing sectors.

This indicator often used to analyze the energy efficiency of a specific nation. In general, the ratio of energy use to GDP is used to assess how well the economy is utilizing its energy in terms of monetary output

b. Unit of measure

Toe/ Thousand 2015 USD

c. Methodology

The data for indicator 'total energy supply by GDP' under 'energy supply' was directly retrieved the International Energy Agency website.

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- Data source

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e. References

IEA (2021) Indicator: The total energy supply by GDP under 'energy supply'. The International Energy Agency. Available at: https://www.iea.org/data-and-statistics

2.3 Water intensity of the economy

a. Indicator description

It is the measure of the use of water (liter) to earn a dollar. All the nations under study have improved their water use efficiency.

The purpose of water intensity is to measure It is the measure of the use of water (liter) to earn a dollar in term of liter per dollar.

b. Unit of measure

Liter per dollar

c. Methodology

Water intensity of the economy was estimated by taking the ratio of total water withdrawal of the country and GDP of the country.

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Data of water use and GDP was collected from FAO and World bank respectively. it is freely available at the country level. There is no need of any sort of permission. The source of data available at given link: FAO (http://www.fao.org/aquastat/statistics/query/index.html;jsessionid=78FFD3BAAF9A95E0880C546521126444)

e. References

FAO [AQUASTAT]. License: CC BY-NC-SA 3.0 IGO. Extracted from: [http://www.fao.org/aquastat/statistics/query/index.html;jsessionid=78FFD3BAAF9A95E0880C546521126444]. Data of Access: [14-03-2022].

World Bank. (2021). Population, total. [Data set]. World Development Indicators. Available at https://data.worldbank.org/indicator/SP.POP.TOTL.

2.4 GHG intensity of the economy

a. Indicator description

GHG emission intensity can be defined as the amount of GHG emissions per gross domestic product. This indicator represents the GHG intensity of the production processes (energy-related emissions) i.e., the GHG emission intensity associated with the production of input materials and logistics of a product. This can be done for the economy as a whole or for specific industries.

b. Unit of measure

The GHG intensity is usually measured in metric tonnes of CO_2eq per GDP.

c. Methodology

Total CO_2 emissions for an economy are estimated based on energy consumption data for all sectors. CO_2 emissions from manufacturing are based on energy data collected across sectors. Energy data are collected at a country level, based on internationally agreed standards (UN International Recommendations on Energy Statistics (IRES)). The estimates of CO_2 emissions from fuel combustion are calculated by the IEA based on the IEA energy data and the default methods and emission factors from the 2006 IPCC Guidelines for National GHG Inventories.

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- Data source

The IEA collects energy data at the national level according to harmonised international definitions and questionnaires, as described in the UN International Recommendations for Energy Statistics. The data sources are given below;

UNIDO (https://www.unido.org)

INDSTAT (https://stat.unido.org/)

https://www.iea.org/reports/co2-emissions-from-fuel-combustion-2019

The International Energy Agency: https://www.iea.org/data-and-statistics

e. References

IEA (2021), Greenhouse Gas Emissions from Energy: Overview, IEA, Paris. Available at : https://www.iea.org/reports/greenhouse-gas-emissions-from-energy-overview

3 Resource use in major sectors

3.1 Emissions of the energy sector

a. Indicator description

Direct GHG emissions that are produced in the generation and transmission of energy are a relevant indicator of both the carbon efficiency with which energy services are provided, and the scale of the energy needs of a society. This section looks at the environmental impacts from the perspective of climate change. While many countries in the Asia Pacific region have reduced their energy intensity in terms of megajoules per unit of GDP, a great deal of this energy transition has come about through new coal-fired power. This investment may even replace more emissions-intensive technology, but the total emissions produced from the energy sector are due to a combination of the carbon intensity of energy production, the consumption of energy per capita and the population growth. This indicator looks at the environmental impacts by the energy sector from the climate change perspective.

b. Unit of measure

Tonnes of CO_2eq and tonne of CO_2 equivalent /toe

c. Methodology

The data for indicators 'GHG emissions of the energy sector' and 'CO_2 intensity of energy mix' was retrieved from the International Energy Agency website.

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e. References

IEA (2021) Indicators: GHG emissions of the energy sector and CO_2 intensity of energy mix. The International Energy Agency. Available at :https://www.iea.org/data-and-statistics

4 Consumption-based indicators for natural resource use

4.1 Material Footprint

a. Indicator description

When economies develop, they import final goods to replace a large portion of the domestic production of final goods, and the extractive activities on which they rely. The upstream primary material requirements for those commodities, as well as the associated environmental impact, remain in the country of production. This is how developed economies outsource their material-intensive activities to developing countries. This process has enabled wealthier economies to minimize their dependence on resource extraction. Material footprint of consumption is an attribute of global material extraction to final demand including the final consumption of households, governments, and capital investment. The indicator provides information about the actual primary material demand of any economy without including the extraterritorial trade intervention. Also, the indicator reports the actual quantity of primary materials consumption and the capital investment a country relies upon independently from where the material extraction has occurred in the global economy.

b. Unit of measure

Tonnes

c. Methodology

Material footprint of consumption is an attribute of global material extraction to final demand including the final consumption of households, governments, and capital investment. The data for material footprint was derived for 18 Asia Pacific developing countries and 6 developed countries for the time series 2010 to 2017. The data for material footprint was obtained from the UNEP databank. The obtained data is presented in the form of bar charts to assess and compare situation of the material footprint in all concerned countries from various angles.

d. Terms of conditions

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The data for total material footprint (MF, tonnes) and material footprint (MF per capita, tonnes per capita) is free to access.

- Data source

The global material flows database is based on country material flow accounts from the European Union and Japan and estimated data for the rest of the world. Estimated data is produced on the bases of data available from different national or international datasets in the domain of agriculture, forestry, fisheries, mining, and energy statistics. International statistical sources for DMC and MF include the IEA, USGS, FAO and COMTRADE databases.

The data for DMC was obtained from the Global Material Flows Database. The available data is ready to use and very easy to access. Moreover, the data is publicly available, and there is no limitation regarding data usage. The source of data available at given link: “Global Material Flows Database.” (https://www.resourcepanel.org/global-material-flows-database (March 11, 2022))

e. References

UNEP IRP 2019. Global Material Flows Database. Available at: https://www.resourcepanel.org/global-material-flows-database

The World Bank Databank. 2022. World Development Indicators. The World Bank. [Last accessed on 14.03.2022], [Online available at: https://databank.worldbank.org/home.aspx]

4.2 Water Footprint

a. Indicator description

The water footprint of a country is equal to the total volume of water used, directly or indirectly, to produce the goods and services consumed by the inhabitants of the country (Chapagain and Hoekstra, 2004). Pre-calculated data for all the countries under consideration from 1990 to 2015 is available at Eora global, multi-regional input-output framework developed by the University of Sydney (Lenzen et al., 2013; Eora global, 2015). In this report, pre-calculated data of total water footprint was used for illustrating country profiles.

b. Unit of measure

Cubic meter

c. Methodology

Water footprint was calculated by the pre-calculated data of total water footprint by adding the green water and blue water footprint only.

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- Data license

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- Data source

Water footprint data was collected from Eora global 2021 (https://www.worldmrio.com/countrywise/). It is freely available. But there is a need to sign in by official email account and need to explain the purpose of use.

e. References

Chapagain, A.K ،and Hoekstra, A.Y. 2004. Water footprints of nations Volume 1 :Main Report ، IHE Delft Institute for Water Education ،Available at : https//:www.waterfootprint.org/media/downloads/Report16Vol1.pdf

Eora global. 2015. Eora National IO Tables. Available at :https//:worldmrio.com/countrywise/

Lenzen, M ., Moran, D ., Kanemoto, K ،& Geschke, A ،2013. Building Eora :a global multi -region input-output database at high country and sector resolution ،*Economic Systems Research, 25*)1(, 20–49 ،https//:doi.org/10.1080/09535314.2013.769938

5 Trade dependency

International trade has been increasing due to the wave of globalization. The specific policy context is essential, as to whether a country is a net importer or net exporter of primary resources. Importer countries can reduce their dependency on imported primary resources by pursuing higher resource productivity whereas exporter countries might seek policies by strengthening export diversification. It is also important for the prevention of the Dutch Disease (an economic phenomenon entailing rapid development of one sector while declining in other sectors) via reducing the serious imbalances of payments between countries' unit prices of imports and exports.

5.1 Physical Trade Balance (PTB)

a. Indicator description

To determine whether a country is an importer or exporter, physical trade balance (PTB) is a selected indicator representing the trade status. The PTB measures material flows by subtracting the exports from the imports (in metric tonnes). The PTB provides information on whether a country depends on resources from abroad (positive PTB; a net importer) or supplies physical goods to the world market (negative PTB; a net exporter).

b. Unit of measure

Tonne; tonne per capita

c. Methodology

PTB (tonne); The PTB is calculated by subtracting the exports from the imports (in metric tonnes.)

PTB (tonne per capita); The PTB in tonne per capita is calculated as imports minus exports of country and then divided by its total population.

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- Data source

To access PTB dataset from the Global Material Flows Database, there is needed to fill contact details in the form on its website .After that the website will allow to select dataset to download. For population, it can get the data from World Bank website that is free to access.

CSIRO (https://materialflows.csiro.au/forms/form-mf-start-world.aspx)

e. References

CSIRO (2017). Global Material Flows Database. United Nations Environment Programme International Resource Panel Global Material Flows Database. Available at: https://materialflows.csiro.au/forms/form-material-flows-world.aspx.

World Bank. (2021). Population, total [Data set]. World Development Indicators. https://data.worldbank.org/indicator/SP.POP.TOTL

5.2 Unit price of trade

a. Indicator description

The unit price of the trade is related to countries' monetary income (expenditure) for each unit mass of exports (imports) showing the cost in kilogram. The economy will become stronger if the monetary income per unit of that country is greater than its monetary expenditure. The monetary base used is dollar at constant year 2010 exchange rate value, sourced from World Bank (2021). The same import and export volumes from previous section (PTB) were used to calculate unit price of trade. To report the relationship between how much money a country pays for its imports and how much it receives from its exports

b. Unit of measure

$ per kg

c. Methodology

In order to report in constant 2010 prices, the annual income /expenditure need to multiply by consumer price index .

Unit prices of exports (UPE)

The unit prices of exports is calculated as the country's monetary income from exports divided by its total exports.

Unit prices of imports (UPI)

The unit prices of imports is calculated as the country's expenditure from imports divided by its total import.

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WTO (2022). Statistics Database. Available at: https://stats.wto.org

The value indices are calculated by the WTO based on the WTO-UNCTAD annual merchandise trade dataset. Unit value indices are sourced from national sources, ECLAC, EUROSTAT, and estimated when necessary, as a joint production of UNCTAD and the WTO. Volume indices are produced by the WTO by deflating the value indices by the unit value indices.

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- Data source

The data of total imports and exports is obtained from the Global Material Flows Database, which is the same data source of PTB .The data of countries' monetary income and expenditure can assess from Unctadstat website which is free to use .For consumer price index, it can get the data from World Bank website that is also free to access.

UNCTADstat (https://unctadstat.unctad.org/EN/BulkDownload.html)

e. References

CSIRO (2017). Global Material Flows Database. United Nations Environment Programme International Resource Panel Global Material Flows Database. Available at: https://materialflows.csiro.au/forms/form-material-flows-world.aspx.

IMF (2022). International Financial Statistics. Available at: https://data.imf.org/?sk=4c514d48-b6ba-49ed-8ab9-52b0c1a0179b .

WTO (2022). Statistics Database. Available at: https://stats.wto.org

World Bank. (2021). Consumer price index [Data set]. World Development Indicators. https://data.worldbank.org/indicator/FP.CPI.TOTL

6 Resources and human development

6.1 Human Development Index (HDI)

a. Indicator description

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.

b. Unit of measure

Unitless

c. Methodology

The Human Development Index (HDI) is a measure of human development. HDI consists of three different domains, viz., literacy rate, life expectancy, and standard of living. It can be calculated by taking weighted average of literacy rate, life expectancy ratio, and GNI per capita

d. Terms of conditions

- Data source

“Human Development Data Center” (http://hdr.undp.org/en/data (October 7, 2021))

“World Development Indicators | DataBank.” (https://databank.worldbank.org/source/world-development-indicators (October 7, 2021))

e. References

United Nations Development Programme 2020. Human Development Data Center. Available at: http://hdr.undp.org/en/data

The World Bank Databank. 2022. World Development Indicator. The World Bank. [Last accessed on 14.03.2022], [Online available at: https://databank.worldbank.org/home.aspx]

6.2 Economic growth (GDP)

a. Indicator description

Gross domestic product (GDP) is the most commonly used indictor for measuring economic growth. 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 activities provide a different perspective on domestic material consumption and material footprint in concerned Asia Pacific developing countries.

b. Unit of measure

$ (annual USD)

c. Methodology

Gross domestic product (GDP) is the most commonly used indicator for measuring economic growth. 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 broad estimate of overall domestic production of any region. The data for GDP was derived for 18 Asia Pacific developing countries for the time series 2010 to 2017. The GDP data was obtained from the World Bank databank. The obtained GDP data is to show how overall production activities provide a different perspective on domestic material consumption and material footprint in concerned Asia Pacific developing countries.

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World Bank (https://data.worldbank.org/)

e. References

The World Bank Databank. 2022. World Development Indicators. The World Bank. [Last accessed on 14.03.2022], [Online available at: https://databank.worldbank.org/home.aspx]

6.3 Investment and consumption

a. Indicator description

Investment is the allocation of current financial resources in order to achieve higher gains in the long run. In the economic perspective, it can also be defined as the value of fixed capital assets (and stocks) produced over a specific period of time and it also refers to the creation of capital goods. Investment proves to be an injection into the circular flow of income. On the other hand, consumption specifies total expenditure on goods and services that are used to satisfy needs during a specific time period. In economics, it is the use of goods and services by households and also refers to the flow of households' spending or goods and services which yield utility in the current period. Direct investment is a category of cross-border investment associated with a resident in one economy.

b. Unit of measure

Percentage of GDP

c. Methodology

The data for indicator 'Foreign direct investment, net inflows (% of GDP)' under 'Economy and growth' was retrieved form the World Bank.

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World Bank (https://data.worldbank.org/indicator)

e. References

World Bank. (2021). 'Foreign direct investment, net inflows (% of GDP)' under Economy and growth [Data sets]. Available at: https://data.worldbank.org/

6.4 Debt, inflation

a. Indicator description

Two indicators have been used to analyze the economic performance of selected nations in Asia Pacific region: the general government debt (expressed in terms of percentage of the GDP) and inflation rate (expressed in terms of annual percentage change in average consumer prices). The general government gross debt indicates the overall accrued external financial obligations which are accumulated to finance expenditures above the generated revenues. On the other hand, in economics, inflation is the rise of the price level in an economy over a specific time period. The rise in general prices causes the currency unit to be able to buy lesser goods and services thus reflecting the reduction in the purchasing power. Ultimately, it creates a loss of real value in the medium of exchange and unit of account within the economy.

b. Unit of measure

Percentage of GDP, Annual percentage change in average consumer prices

c. Methodology

The data for indicators 'inflation rate' and 'The general government gross debt' were retrieved form the International Monetary Fund (IMF) website.

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International Monetary Fund (IMF)

(https://www.imf.org/external/datamapper/PCPIPCH@WEO/WEOWORLD/VEN/IRN)

e. References

IMF. (2021). Indicator: 'inflation rate'. *International Monetary Fund (IMF)*. Available at: https://www.imf.org/external/datamapper/PCPIPCH@WEO/WEOWORLD/VEN/IRN

IMF. (2021). Indicator: 'The general government gross debt'. *International Monetary Fund (IMF)*. Available at: https://www.imf.org/external/datamapper/GGXWDG_NGDP@WEO/OEMDC/ADVEC/WEOWORLD

6.5 Access to energy, water, and sanitation

To improve the standard of living which is related to human development, provision of access to electricity, water, and sanitation are taken into consideration. These three indicators are correlated with not only the standard of living (Rao and Pachauri, 2017) but also economic development (Sušnik and Van der Zaag, 2017; Burke et al., 2018).

6.5.1 Access to electricity and water

a. Indicator description

This indicator is measured as the percentage of people with access to electricity. Data on access to electricity from 2000 to 2019 of 18 countries in the Asia Pacific region was obtained from World Bank (World Bank, 2019). Missing data were filled by linear interpolation technique. Access to electricity is also correlated with economic growth. While, access to water means access to drinking water services. It is measured as the percentage of people with access to drink water services. Data of people using safely managed drinking water services from 2000 to 2020 of 14 countries in the Asia Pacific region was obtained from the Global SDG Indicators Database (United Nations, 2021).

Electricity access is measured as the percentage of people with access to electricity. While, access to water is measured as the percentage of people with access to drinking water services.

b. Unit of measure

Percentage of population

c. Methodology

Access to electricity and water was estimated in terms of percentage of population of a country.

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Website: (https://data.worldbank.org/; https://washdata.org; https://washdata.org)

Access to drink water services was obtained from Global SDG Indicators Database

e. References

Burke, P.J., Stern, D.I., & Bruns, S.B) ،2018 ،(The Impact of Electricity on Economic Development : A Macroeconomic Perspective ،*International Review of Environmental and Resource Economics*, *12*(1), 85-127 ،https://doi.org/10.1561/101.00000101.

Rao, N ،and Pachauri, S) ،2017 ،(Energy access and living standards :Some observations on recent trends ،*Environmental Research Letters, 12*) 2(, 025011 ،https//:doi.org/10.1088/1748-9326/aa5b0d

Sušnik, J., and Van der Zaag, P) ،2017 ،(Correlation and causation between the UN Human Development Index and national and personal wealth and resource exploitation. *Economic Research-Ekonomska Istraživanja, 30*)1(, 1705-1723 ، https//:doi.org/10.1080/1331677X.2017.1383175

World Bank. (2019). Access to electricity (% of population) [Data set]. World Development Indicators. Available at: https://data.worldbank.org/indicator/EG.ELC.ACCS.ZS

WHO and UNICEF 2020. Joint Monitoring Programme Global Database. Available at: https://washdata.org

6.5.2 Access to sanitation

a. Indicator description

Access to sanitation means access to sanitation services. It is measured as the percentage of people with access to sanitation services. The sanitation facility is not shared with other households and excreta are safely disposed of in situ or treated off site. Data of people using sanitation services from 2000 to 2020 of 11 countries in the Asia Pacific region was obtained from Global SDG Indicators Database (United Nations, 2021). It is measured as the percentage of people with access to sanitation services.

b. Unit of measure

Percentage of population

c. Methodology

Access to sanitation was estimated as the percentage of the country's population have access.

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- Data source

Access to sanitation data was collected from Joint Monitoring Programme (https://washdata.org)

e. References

WHO and UNICEF 2020. Joint Monitoring Programme Global Database. Available at: https://washdata.org.

7 Inclusive green recovery

7.1 COVID spending

a. Indicator description

In 2020, the global economy shrank by approximately 3.5% due to the pandemic (IMF, 2021). The lockdown measures have crippled the economic activities; consequently, depreciating or at least burdening the countries through unemployment, wage cuts, and disease burden. The data for COVID spending was retrieved from the International Monetary Fund (IMF) database, which summarizes the key fiscal measures taken by governments in response to the COVID-19 pandemic (FAD, 2021). The database categorizes different types of fiscal support (i.e., equity, loans, and guarantees, and additional spending/forgone revenues) while focusing the discretionary measures that supplement existing automatic stabilizers.

The equity, loans, and guarantees are different forms of assistance provided to beneficiaries for investment in research and innovation. The guarantees are provided to beneficiaries so that they can borrow loans from financial institutions at better conditions. On the other hand, additional spending or forgone revenue consists of temporary tax cuts, and liquidity support, including loans, guarantees, and capital injections by the public sector. To analyze the fiscal measure taken by the selected economies in the Asia Pacific region.

b. Unit of measure

Percent of 2020 GDP

c. Methodology

The data for indicator ’Country fiscal measures in response to the COVID- 19’ was directly retrieved form the International Monetary Fund (IMF) website.

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(https://www.imf.org/en/Topics/imf-and-covid19/Fiscal-Policies-Database-in-Response-to-COVID-19)

International Monetary Fund (IMF): https://www.imf.org/en/Data

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FAD (2021). Fiscal Monitor Database of Country Fiscal Measures in Response to the COVID-19 Pandemic .International Monetary Fund. Available at : https//:www.imf.org/en/Topics/imf-and-covid19/Fiscal-Policies-Database-in-Response-to-COVID-19

IMF. (2021). World Economic Outlook Update, January 2021: Policy Support and Vaccines Expected to Lift Activity. International Monetary Fund. Available at: https://www.imf.org/en/Publications/WEO/Issues/2021/01/26/2021-world-economic-outlook-update

7.2 Natural capital

a. Indicator description

Natural capital plays a crucial role in sustaining the global economies. It is now more important than ever to take decisive action against deforestation or natural disasters to protect and rebuild it. In general, low skills are required for jobs from natural capital investments and can enhance employment opportunities targeted to demographics that are particularly struggling during the pandemic (Edwards et al., 2013).

The indicator includes the valuation of fossil fuel energy (oil, gas, hard and soft coal) and minerals (bauxite, copper, gold, iron ore, lead, nickel, phosphate, silver, tin, and zinc), agricultural land (cropland and pastureland), forests (timber and some nontimber forest products), and protected areas.

Gross Domestic Product (GDP) looks at only one part of economic performance—income—but says nothing about wealth and assets that underlie this income. For example, when a country exploits its minerals, it is depleting wealth. However, natural capital is the valuation of natural resources of any economy.

b. Unit of measure

Constant 2014 US dollars

c. Methodology

The data for indicator 'natural capital' was directly retrieved form the World Bank (https://data.worldbank.org/). Values are measured at market exchange rates in constant 2014 US dollars, using a country-specific GDP deflator.

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e. References

World Bank. (2021). Indicator: 'Natural capital'. *Wealth Accounts - World Bank Databank*. (https://databank.worldbank.org/source/wealth-accounts/Type/TABLE/preview/on#)

Edwards, P.E.T., Sutton-Grier, A.E., & Coyle, G.E. (2013). Investing in nature :Restoring coastal habitat blue infrastructure and green job creation .*Marine Policy*, *38*, 65–71 . https//:doi.org/10.1016/j.marpol.2012.05.020

7.3 Green spending

a. Indicator description

The spending's data for the Asia pacific region is retrieved from the Global Recovery Observatory which tracks and assesses every individual COVID-19 related fiscal spending policy announced by the leading economies worldwide for potential impacts on the environment and the socio-economy. Data is focusing on 'recovery' spending as opposed to 'rescue' spending. Each policy and it's relative 'greenness' based on potential impact on long- and short-term GHG emissions, air pollution, natural capital, quality of life, inequality and rural livelihood can further be explored on the official website. However, the three general categories (i.e., green, recovery, and total spending) are included in this analysis (O'Callaghan et al., 2020).

The spending's data for the Asia pacific region is retrieved from the Global Recovery Observatory which tracks and assesses every individual COVID-19 related fiscal spending policy announced by the leading economies worldwide for potential impacts on the environment and the socio-economy.

b. Unit of measure

USD per capita

c. Methodology

The data for indicator 'Green spendings' was retrieved form the Oxford University Economic Recovery Project (OUERP)

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e. References

O'Callaghan, B., Yau, N., Murdock, E., Tritsch, D., Janz, A., Blackwood, A., Purroy Sanchez, L., Sadler, A., Wen, E., Kope, H., Flodell, H., Tillman-Morris, L., Ostrovsky, N., Kitsberg, A., Lee, T., Hristov, D., Didarali, Z., Chowdhry, K., Karlubik, M., Shewry, A., Bialek, F., Wang, M., Rosenbaum, N., Gupta, S., Hazell, T., Angell, Z., & Hepburn, C) .2020.(Global Recovery Observatory. Oxford University Economic Recovery Project. Available at: https//:recovery.smithschool.ox.ac.uk/tracking/

O'Callaghan, B., Bird, J., & Murdock, E. (2021*).* A Prosperous Green Recovery for South Africa. Oxford University Economic Recovery Project, SSEE and Vivid Economics in partnership with the United Nations Economic Commission for Africa.

7.3.1 Green energy investments

a. Indicator description

Green energy comes from natural or renewable resources; therefore, it has less environmental impacts leading to a cleaner and more sustainable energy. Green energy investments have high potential to attract the private investors and play a crucial role in economy-wide decarbonization. Strong benefits can also be obtained from the new renewable generation, transmission investments, distribution (including smart grids), and energy storage solutions. Employment opportunities for these investments can be strong compared to traditional energy initiatives, particularly in the short-term (Dvořák et al., 2017).

b. Unit of measure

Percentage (%)

c. Methodology

The data for the indicator 'Clean energy and climate mitigation investments' was retrieved from the Asian Development Bank (ADB) (https://www.adb.org/publications/financing-clean-energy-developing-asia).

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Asian Development Bank (ADB) (https://www.adb.org/publications/financing-clean-energy-developing-asia).

e. References

Dvořák, P., Martinát, S., der Horst, D. V., Frantál, B., & Turečková, K. (2017). Renewable energy investment and job creation; a cross-sectoral assessment for the Czech Republic with reference to EU benchmarks. *Renewable and Sustainable Energy Reviews, 69*, 360–368. https://doi.org/10.1016/j.rser.2016.11.158

7.3.2 Green transport

a. Indicator description

Effective and environmentally friendly travelling method with less emissions, pollution, and consumption is the simplified concept of green transportation. Transportation is one of the major components of current GHG emissions; therefore, decarbonizing the sector is crucial for meeting climate targets. Two indicators were selected to analyze the status que of the transport sector in green perspective: electricity demand from the global EV-fleet and biofuel production in 2019 compared to consumption in 2030 under the sustainable development scenario.

b. Unit of measure

TWh, Mtoe

c. Methodology

The indicator selected to assess the electromobility in the Asia Pacific region is 'Electricity demand from the global EV-fleet by country or region-2030' and measured in terms of TWh. Another indicator selected to assess the green transport status in the region is 'Biofuel production in 2019 compared to consumption in 2030 under the sustainable development scenario'. The data was retrieved from the International Energy Agency (IEA) data bank.

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- Data source

(https://www.iea.org/data-and-statistics/charts/electricity-demand-from-the-global-ev-fleet-by-country-region-2030)

(https://www.iea.org/data-and-statistics/charts/biofuel-production-in-2019-compared-to-consumption-in-2030-under-the-sustainable-development-scenario)

e. References

Unsworth, S., Valero, A., Martin, R., & Verhoeven, D. (2020). Seizing sustainable growth opportunities from zero emission passenger vehicles in the UK. LSE Growth Commission. Available at: https://www.lse.ac.uk/granthaminstitute/wp-content/uploads/2020/02/GRI_Seizing-sustainable-growth-opportunities-from-zero-emissions-passenger-vehicles-in-the-UK_FULL-REPORT.pdf

7.3.3 Green research and development

a. Indicator description

In any economic recovery package, there is a role for longer-acting stimulus. Furthermore, the long-term and short-term acting measures can be combined to ensure the economic growth. It may help accelerate investment to create new long-term demand and industrial capability, rather than only shifting future demand backwards. Green R&D policies could be a vital component of meeting the 2030 Sustainable Development Goals, (SDG goals no. 7, 9, 11, 12, and 13).

b. Unit of measure

Constant 2019 USD

c. Methodology

The indicator 'Dollar value of financial and technical assistance committed to developing economies' is the selected to assess the green research and development in the Asia Pacific region. The dataset is retrieved from the Asia Development Bank-Key Indicators Database. This indicator is in accordance with the SDG Target 17.9: Enhance international support for implementing effective and targeted capacity-building in developing economies to support national plans to implement all the Sustainable Development Goals, including through North-South, South-South, and triangular cooperation.

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Asian Development Bank (ADB) (https://kidb.adb.org/themes/sustainable-development-goals)

e. References

ADB. (2021). Indicator: Dollar value of financial and technical assistance committed to developing economies under SDG 17.9. *Asian Development Bank (ADB).* Retrieved from: https://kidb.adb.org/themes/sustainable-development-goals

Useful links for global resource efficiency situation

SCP Hotspots Analysis Tool

Website: http://scp-hat.lifecycleinitiative.org/

Food and Agriculture Organization of the United Nations

Website: https://www.fao.org/home/en

The World Bank

Website: http//:data.worldbank.org/

United Nations Development Programme

Website: http://hdr.undp.org/en/data

United Nations Environment Statistics

Website: https://unstats.un.org/unsd/envstats

United Nations Industrial Development Organization

Website: https://unhabitat.org/

United Nations Human Settlement Programme

Website: https://unhabitat.org/

The Commonwealth Scientific and Industrial Research Organisation

Website: https://www.csiro.au/en/

International Energy Agency

Website: https://www.iea.org/

International Monetary Fund

Website: https://www.imf.org/en/Home

Global SDG Indicators Database

Website: https://unstats.un.org/sdgs/dataportal

Asian Development Bank

Website: https://www.adb.org/