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Green and Digital: Managing the Twin Transition toward Sustainable Development

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Abstract

The global shift toward sustainability and increased digitalization is evident. Nations are integrating renewable energy, carbon emission reduction, and advancements in green technologies into their development plans. Simultaneously, Industry 4.0 has revealed the diverse ways technology influences human life. Rather than separate factors, these dual forces are interconnected elements that countries must navigate for sustainable progress. As countries continue to pursue development strategies, taking a closer look on this twin phenomenon is important. This study assesses how investments, labor, science, technology, innovation, and artificial intelligence contribute to this dual transformation. Through desk reviews and synthesized data, this paper highlights relevant initiatives, technology-related risks, and recommendations for addressing existing gaps.

The study acknowledges existing government initiatives aligned with green transition and digitalization. However, it identifies persistent issues, such as inadequate investment in clean climate technologies, shortage of skilled workers in green sectors, and uncertainties regarding the sustainability of AI. To overcome these challenges, the paper proposes directions to bridge gaps, remove barriers to participation, and enhance capabilities, aiming to fully harness the potential of this combined transition.

Keywords: Green transition, digitalization, labor, artificial intelligence, green investments, science, technology and innovation

Table of Contents

List of Tables

List of Figures

List of Appendices

List of Acronyms

ADB - Asian Development Bank
AI - Artificial Intelligence
APEC – Asia-Pacific Economic Cooperation
ASEAN – Association of Southeast Asian Nations
CHED – Commission on Higher Education
DepEd – Department of Education
DICT – Department of Information and Communications Technology
DOLE – Department of Labor and Employment
DOST – Department of Science and Technology
DTI – Department of Trade and Industry
EBT – enterprise-based training
FAO – Food and Agriculture Organization
GDP – gross domestic product
GPS – global positioning system
GVC – global value chain
HEI – higher education institution
ICT – information communications technology
IFC – International Finance Corporation
ILO – International Labour Organization
IoT – Internet of Things
IT-BPM – Information Technology and Business Process Management
LCOE – levelized cost of electricity
LEED – Leadership in Energy and Environmental Design
LEP – Labor and Employment Plan
LGU – local government unit
NAST – National Academy of Science and Technology
NEDA – National Economic Development Authority
NIASD – National Innovation Agenda and Strategy Document
NTESDP – National Technical Education and Skills Development Plan
PDP – Philippine Development Plan
PEDP – Philippine Export Development Plan
PEP – Philippine Energy Plan
PRC – Professional Regulation Commission
PSA – Philippine Statistics Authority
PSOC – Philippine Standard Occupation Codes
R&D – research & development
SDG – Sustainable Development Goal
STEM – science, technology, engineering, and mathematics
STI – science, technology, and innovation
TESDA – Technical Education and Skills Development Authority
TVET – technical and vocational education and training
UI – unemployment insurance
USD – United States Dollar

Green and Digital: Managing the Twin Transition toward Sustainable Development

Francis Mark A. Quimba[1], Ramonette B. Serafica[2], Connie Bayudan-Dacuycuy[3], Neil Irwin S. Moreno[4], and Abigail E. Andrada[5]

1. Introduction

The world is undergoing a green transition and rapid digitalization. Green transition is evident in countries adapting their development plans to incorporate strategies related to shifting to renewable energy, reducing carbon emissions, and strengthening green technologies. Meanwhile, digitalization was catalyzed by COVID-19 and countries have continued to utilize digital technology in various aspect of the economy. The advent of Industry 4.0 has brought to light the various applications through which technology can affect human life.

These twin forces acting on economies, however, should not be seen as separate forces but rather simultaneous factors that countries need to navigate in order to ensure sustainable development. Green transition strategies are increasingly becoming more dependent on digital technology to ensure efficient use of resources. Digitalization, on the other hand, requires the use of renewable energy to reduce the energy consumption of the digital infrastructure and digital transactions.

Countries of all income levels are engaged in this dual transformation: green transition and digitalization. For countries like the Philippines which is bearing the brunt of climate change, science, technology and innovation (STI) offer avenues and strategies for greater resilience by presenting new ways to adapt and reduce the negative impact of destructive storms, fires, droughts and other calamities. Working towards a green economy is also important for the country as it works towards the achievement of its 2040 vision of a strongly rooted (*Matatag*), comfortable (*Maginhawa)*, and secure (*Panatag*) future for all.

This paper begins by expounding on the twin transition by presenting the simultaneous forces of the green transition and rapid digitalization occurring globally. It then discusses the concept of the twin transition and relates the twin transition to sustainable development. Issues and concerns are also presented. The paper proceeds to relating the twin transition to the Philippine context and puts forth important issues that the country needs to address to make the twin transition work for the development of the country such as the possible impact on trade and investment, the readiness of human capital, and the role of science and technology including the role of artificial intelligence in the twin transition. Finally, the conclusion presents the role of government and discusses how the government should manage the twin transition.

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2. Background

2.1. The world is undergoing a green transition and…

Faced with the issues related to climate change and disaster resilience[6], countries have agreed to collectively respond to the challenges of climate change. In the 2021 Glasgow Climate Pact, more commonly referred to as COP26, countries have dedicated 2020-2030 as a decade for climate action and support with the goal of reducing emissions and capping the global average temperature rise to 1.5 degrees.

As countries adapted their national policies with the 2030 Agenda for Sustainable Development and the Paris agreement, they have also engaged in a gradual transition to 'green' economies. Appendix 1 shows that countries, regardless of geographic location and size of the economy, have adopted the green transition into their development plans. European countries (e.g. Germany, France, Spain) have even allocated significant resources to achieve carbon emissions reduction targets. In the region, ASEAN countries and their neighbors have committed reductions to carbon emissions by 2050 incorporating these commitments to updated development plans (Appendix 1).

Countries are also exploring the shift to smarter production and consumption as well as the adoption of renewable sources of energy. As the cost–benefit ratio of non-renewable energy rises, 'green' energy projects have multiplied. With the rise in energy security concerns and new policies being developed, the International Energy Agency has observed an unprecedented momentum for renewable energy adoption. In 2012, the share of primary energy consumption that came from renewable energy technologies (e.g. hydropower, solar, wind, geothermal, wave, tidal, and modern biofuels) made up 8.8% of global electricity generation. By 2022, the figure has increased to 14.21% of the world's total energy generation.

A fall in the cost of renewable energy is one of the biggest factors in its rapid adoption. Particularly in offshore wind, the global weighted-average cost of electricity of new projects saw a 9% year-on-year decline in 2020 from USD 0.093/kWh to USD 0.084/kWh (IRENA 2021). On the other hand the global weighted average of levelized cost of electricity (LCOE) of utility-scale solar photovoltaics (PV) recorded a 7% year-on-year decline from USD 0.061/kWh to USD 0.057/kWh (IRENA 2021). Together solar and wind energy sources are now cost competitive with electricity generated from fossil fuels (Jaeger et. al. 2021).

While reduced costs are a major factor in the rapid adoption of renewable energy technologies, policy support has also been essential for its growth. Policies such as renewable energy tax subsidies and credits have helped reduce costs and propel deployment. Government investment in research and development has also been fundamental in promoting innovation in renewable energy (Jaeger et. al. 2021)

2.2. …at the same time, facing rapid digitalization

In parallel to their green transition, countries have worked towards the adoption of digital technology such as the digitalization of services and payment systems to improve service

[6]The dramatic changes to the world's climate and the unprecedented temperature records have been related to more frequent and disastrous weather phenomenon such as typhoons, heatwaves, snowstorms and others. According to the World Meteorological Organization, economic losses from weather-related disasters have increased sevenfold from the 1970s to the 2010s.

delivery, support businesses and combat corruption and tax evasion. Digital technologies have enabled access to more variety and choices of services at lower costs. Convenience and personalized services have also emerged due to new technologies. Consumers also benefit from efficient service delivery due to fewer intermediaries. Compared to the 6.8% global average, in Asia and the Pacific digitally deliverable services have increased at an average of 9% annually (ADB 2022). Digital services have become essential sectors in various economies in Southeast Asia and South Asia.

The Covid-19 pandemic has further heightened the trend and accelerated digitalization (ADB 2022). Mobility restrictions have brought about a surge in digital service delivery as well. Countries pivoted towards digital technologies to continue business transactions, work, remote classes, and government assistance.

Countries have implemented policies fostering the emergence of a digital economy, including smart manufacturing, fintech, e-health services like telemedicine and smart agriculture. Smart manufacturing has raised the competitiveness of firms in APEC economies and thus have led to various policy developments. Several APEC economies have established various plans and programs to strengthen the diffusion of Smart Manufacturing technologies. These include policy programs with fiscal and non-fiscal incentives for stakeholders to adopt Smart Manufacturing technology. The United States' Advanced Manufacturing Partnership (AMP) 2.0 is a collaborative initiative to accelerate the development and adoption of emerging technologies. Similarly, Singapore has launched the Research Innovation and Enterprise (RIE) 2020 plan which aims to establish the country as a global R&D hub (APEC 2019).

To promote financial inclusion, several countries in the Asia-Pacific region have turned to technology and emerging mobile financial services. For instance, India has initiated banking operations in basic mobile devices thus, eliminating the burden of complex banking applications. Similarly, Vietnam's central bank has developed a national strategy to enhance the legal framework of fintech for its development and expansion (Quimba 2021). The Philippine Government's concerted efforts have resulted to regulatory reforms to promote digital payments such as establishment of the National Retail Payment System (NPRS). The interoperable payment infrastructure has laid the foundation for the adoption of digital payment solutions such as InstaPay and PESONet (DTI 2021).

The COVID-19 pandemic has also expedited the adoption of digital technologies for medical and healthcare services such as remote diagnosis, treatment services, and medical training (UNCTAD n.d.). The support of 5G technology, which enables high-speed transmission and sharing of medical information, can alleviate the lack of resources in underdeveloped and rural areas (UNCTAD n.d.). In the Philippines, the Food and Drug Administration has promulgated FDA Circular No. 2020-007 which provides guidelines for the issuance of e-prescriptions.

Improved ICT and digital connectivity have also directly affected agricultural productivity, adaptation to the impacts of climate change; and farmer's well-being. Furthermore, technological advancements in ICT have promoted the increasing adoption of digital delivery of agricultural extension and marketing services (UNCTAD n.d.). Wefarm, the largest global farmer-to-farmer digital network, enables farmers in Kenya to access customized support as well as gain knowledge from peers (Kolk & Ciulli 2020). (UNCTAD n.d.)

The world has begun adopting advanced digital technologies such as artificial intelligence (AI) and robotics, big data, the Internet of Things (IoT) and blockchain technology which are

converging with nanotechnology, biotechnology and cognitive sciences to form the bedrock of the Fourth Industrial Revolution (also known as Industry 4.0). Globally, productivity increases ushered by Industry 4.0 is forecasted to deliver between $1.2 to $3.7 trillion in value. According to McKinsey & Company (2018), ASEAN member states with substantial manufacturing components have the potential to capture productivity gains between $216 to $627 billion.

Clearly, these two paradigmatic transformations have been occurring simultaneously across countries and impacted global industrial systems and societies.

3. Synthesis of qualitative data and desk review

3.1. What is this dual transformation that has been observed recently?

The dual transformation or twin transition (Gigler 2020; UNESCO 2022; Diodato 2023) refers to the mutually interdependent transformations of digitalization and adoption of green processes occurring simultaneously across countries. The digital transformation of the economy and society and the shift to a sustainable model of production should be viewed as closely intertwined and simultaneous.

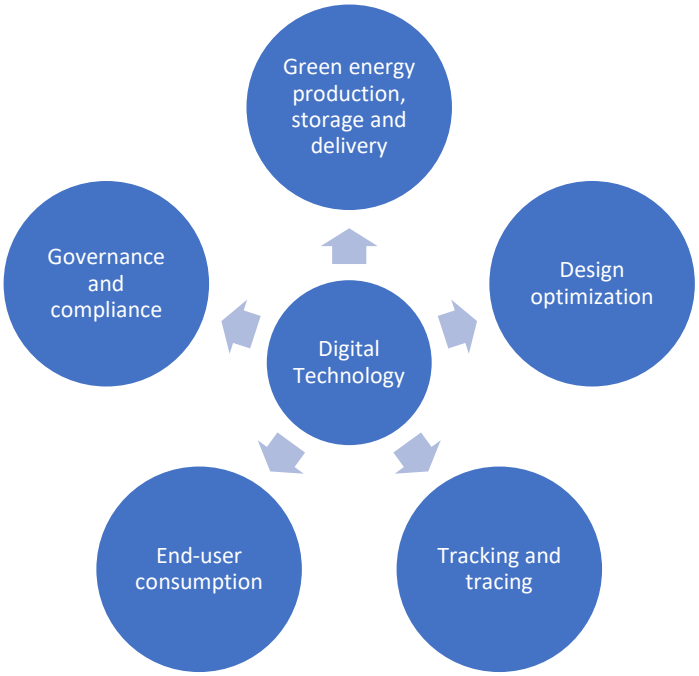
Adopting a cohesive strategy for the twin transition is pivotal to avoiding the pitfalls of pursuing digital and green agendas in isolation. These transitions, while running concurrently, offer an opportunity for synergistic benefits and risk mitigation when interlinked. Considering the expansive impact of these transitions, a thorough examination of their complexities, potential outcomes, and interplay is crucial. The achievement of sustainable development targets hinges significantly on the effectiveness of our green and digital transition strategies. Thus, strategically aligning these transitions is not just beneficial but a necessity for optimizing our collective efforts towards sustainable and technologically advanced business practices.

Digital innovations are indispensable enablers of green transition.

Digital technology can accelerate the green transition across through 5 main classifications of use (Figure 1). These are green energy production, storage and delivery; design optimization; tracking and tracing; consumer consumption and governance and compliance (MIT Technology Review Insights 2023).

Green energy production, storage, and delivery deals with renewable energy sources being intermittent and unstable. These would require smart, decentralized grids to become reliable replacements for hydrocarbon sources. An important technology that illustrates the dual transformation is the use of artificial intelligence in oil, gas and electricity industries (Victor 2019). Machine learning significantly enhances the mapping and valuation of underground oil and gas deposits, enabling cheaper and more efficient extraction. Similarly, AI-assisted training improves the design and operation of wind and solar farms, leading to better use of capital and increased electricity production (Jaldi 2023).

Figure 1. How Digital Technology Enables Business Transformation



Source: MIT Technology Review Insights (2023)

Design optimization, through digital twins and advanced simulations, solves complex problems like maximizing wind turbine energy output or minimizing industrial energy use and waste (MIT Technology Review Insights, 2023). GPS tracking systems, IoT and sensors have been utilized for analyzing global supply chains data and identifying areas for reducing emissions (Mangina et al. 2020).

Tracking and tracing enable the verification of sustainability claims of companies. These claims often require fully traceable digitized supply chains and carbon and emissions tracking. Gigler (2020) explained how blockchain can be a powerful tool to improve the transparency, accountability, and traceability of greenhouse gas emissions. Blockchain can be catalyzed through smart contracts to better calculate, track and report on the carbon footprint of processes across the value chain. Transforming into circular economies needs lifecycle tracking of materials, where blockchain can enhance transparency and verifiability (MIT Technology Review Insights 2023).

End-user consumption is about consumers expecting transparent, personalized insights into choices and usage, with IoT sensors, digital dashboards, and analytics, boosting customer trust and loyalty (MIT Technology Review and Insights 2023). As an example, apps such as Almond help users understand the carbon footprint of their daily activities, including the products they use. Almond provides information about the environmental impact of food and beverage products by scanning their barcodes. Such apps make users more aware of their environmental impact and can lead to more environmentally friendly purchasing decisions (Southey 2019).

Rising needs for data collection and analysis, along with vast data amounts and complexity, demand advanced reporting, data science, and audit tools (MIT Technology Review and Insights, 2023). An example would be the use of advanced technologies such as sensors and or satellite data which enable the gathering and reporting of precise information on tree species

and biodiversity counts have been utilized by international organizations to monitor the implementation of environmental standards in illegal logging and fishing (Gale et al. 2017).

Meanwhile, the greening of digital technologies has become a critical success factor for digital transformation and upgrading.

As concerns for sustainability and efficient resource use increase, Companies are now becoming more conscious in their digitalization strategies. Companies now recognize that while digital technologies are helping in the achievement of their businesses, there is also a need to consider which of these digital technologies are also supportive of the green transition.

Digital technologies, though often seen as 'clean', have a significant environmental impact, primarily through energy consumption and e-waste. Greening these technologies involves reducing their carbon footprint, making them more appealing in a climate-conscious market. Tech giants have been leading the way to transition their operations to more sustainable modes. Google has been working towards using 100% renewable energy for its data centers. As of 2020, they were offsetting all of their electricity with renewable energy certificates and buying power directly from some projects, enabling them to claim 100% carbon-free electricity on paper. However, their data centers were only run on clean energy for 65% of a day on average. Google announced a commitment to achieve 100% renewable power for its data centers and offices by 2030, planning to invest over $5 billion in 5 gigawatts of new clean-energy projects across its supply chain (Shankleman 2020).

Because of the ease of access to information on how goods are manufactured, consumers are increasingly becoming aware of environmental issues associated with the goods they use. This leads to a shift in preference for products and services from companies that demonstrate a commitment to sustainability. Companies that green their digital technologies can differentiate themselves in the market, appealing to both environmentally conscious consumers and business clients. Apple Inc. has been focusing on using recycled materials in its products to appeal to eco-conscious consumers. In 2021, nearly 20% of all material used in Apple products was recycled, with 59% of all aluminum shipped in its products coming from recycled sources. Apple also introduced certified recycled gold in its products and has been working towards eliminating plastics from its packaging by 2025 (Apple 2022). Meanwhile, Fairphone, a smartphone manufacturer, differentiates itself by focusing on sustainable and ethical practices, appealing to a niche market of environmentally and socially conscious consumers (Fairphone 2023)

Companies that lead in adopting and developing green digital technologies can gain a competitive advantage, especially as environmental sustainability becomes a more prominent criterion in procurement decisions. Take the case of global value chains (GVCs). As the GVCs evolve and the governance of the lead firms shift to the use of more sustainable production processes, all stakeholders along the value chain would be forced to acquiesce to the change in policy and ensure technologies adopted support environmental goals. Only firms with the existing capability to adopt technology and innovate processes would be able to be successful in maintaining participation in the GVC. Khattak et al. (2015) cites the case of the apparel industry in Sri Lanka in which lead firms following environmental standards (ISO 14001 and LEED) were able to induce green transition to the suppliers engaged in the production process.

Another reason for integrating green principles to digitalization strategies is that integrating green principles into digital transformation strategies helps in future-proofing businesses

against upcoming environmental regulations and shifts in market preferences. In addition, it also helps companies mitigate risks associated with resource scarcity, regulatory changes, and reputational damage.

For example, IKEA's investment in renewable energy (like wind farms and solar panels) mitigates risks associated with fluctuating energy prices and potential regulatory changes. The Ingka Group, which is a part of IKEA, has invested close to 2.5 billion euros in renewable energy, focusing on both onsite and offsite wind and solar power. This substantial investment has enabled IKEA to generate more renewable energy globally than it consumes. Notably, IKEA now owns 416 wind turbines and 750,000 solar panels, contributing significantly to its energy usage and pushing towards a more sustainable future (Ikea 2023). The company has a goal to become climate positive by 2030, and its investments are a critical step towards this objective (Chapman 2018). Another example is Amazon's Climate Pledge which, demonstrates an effort to align long-term business strategies with environmental sustainability. This commitment aims for the company to reach net-zero carbon emissions a decade ahead of the Paris Agreement's goal. Amazon's dedication to this pledge is evident in their annual updates on sustainability programs, initiatives, and performance. Over 400 companies have joined Amazon in this pledge, highlighting its significance in stimulating investment in the development of low-carbon products and services. (Hurst 2023)

Reputation and corporate image are also key reasons for the greening of digital strategies. Companies that are seen as leaders in sustainability often enjoy enhanced brand reputation and loyalty. Also, there's a growing recognition that corporations have a responsibility to go beyond profit-making and contribute positively to environmental and social issues. Patagonia, known for its environmental activism, extends this ethos to its digital practices, such as minimizing the environmental impact of its e-commerce platforms (Salois 2022). Unilever's Sustainable Living Plan outlines how the company integrates sustainability into its business model, enhancing its image as a socially responsible corporation (Khairunisa and Kusuma 2021).

3.2. Sustainable development and dual transformation

These transformations, once parallel and distinct, are converging. This convergence has implications to sustainable development. How the achievement of sustainable development is aligned with this dual transformation is reflected in the United Nations SDGs underscoring digital technology's potential in supporting the achievement of these goals, with emerging synergies across various sectors of the economy (Microsoft 2023).

The Sustainable Development Goals (SDGs) are linked to the digital and green transition as these are inevitable to achieve sustainable development. Specific SDGS may be directly or indirectly related to the SDGS while some SDGs lie at the intersection of digital transformation and green transition (Box 1). The SDGs are related to the dual transformation and green transition, as achieving sustainable development requires a comprehensive and integrated approach that addresses all these goals.

Box 1. SDGs and the dual transformation

The links of the specific SDGs to the dual transition can be seen in the following:

1. SDG 1: No Poverty: This SDG is relevant to both the digital transformation and green transition, as poverty reduction is a critical aspect of sustainable development. Digital technologies can play a role in providing access to social services (education, healthcare, and financial services) as well as to new job opportunities related to digital technology while the green transition can ensure that the poor have sustainable livelihoods.

2. SDG 2: Zero Hunger: As sustainable agriculture and food production are critical to achieving zero hunger, this SDG is directly related to the green transition and digitalization through strategies related to the optimization of food production and distribution, as well as the reduction of food waste.

3. SDG 3: Good Health and Well-being: This SDG falls into the intersection of the digital transformation and green transition, as access to healthcare and healthy living environments are components of this SDG. Digital technologies can support the development of new healthcare solutions, while the green transition would include goals related to improving air and water quality and reduce exposure to harmful chemicals.

4. SDG 4: Quality Education: Digital transformation supports access to quality education as digital technologies are able to support distance learning and provide access to educational resources. The green transition can benefit from improvements in quality education as there is a need for green skills to be incorporated in the education and training curriculum.

5. SDG 5: Gender Equality: This SDG is relevant to both the digital transformation and green transition, as women and girls are often disproportionately affected by poverty, climate change, and environmental degradation. Ensuring gender equality is essential to achieving sustainable development, and digital technologies can be used to promote gender equality and empower women and girls.

6. SDG 6: Clean Water and Sanitation: This SDG is directly related to the green transition, as preserving water resources are critical to ensuring access to clean water and sanitation. The green transition can promote the sustainable use of water resources and the reduction of water pollution. The development of digital tools to monitor and assess water pollution is one way of relating digitalization to this SDG.

7. SDG 7: Affordable and Clean Energy: Ensuring access to affordable, reliable, sustainable, and modern energy for all is related to green transition. The digital transformation may affect the development and deployment of renewable energy sources, as well as the optimization of energy consumption through the application of data analytics, IoT and artificial intelligence.

8. SDG8: Promotion of sustainable economic growth is related to the development of green industries and the promotion of decent and green jobs. Digital technologies may support the development of new industries and business models.

9. SDG 9: Industry, Innovation, and Infrastructure: Focusing on building resilient infrastructure, promoting inclusive and sustainable industrialization, and fostering innovation, makes this SDG relevant to both the digital transformation and green transition. Investing in green infrastructure such as green transportation systems is an example of a strategy related to both digital technologies, as well as green transition.

10. SDG10: Reduced Inequalities: The use of digital technologies to provide access to services such as education, health care and financial services ensures the achievement of this SDG but there are concerns as well as digital technology access may be unequal developing countries. Green transition also needs to ensure that the most vulnerable who are typically involved in brown industries are protected in the transition to green industries.

11. SDG 11: Sustainable Cities and Communities: This SDG is also relevant to both the digital transformation and green transition. It focuses on building sustainable, resilient, and inclusive cities and communities. Achieving this goal requires investments in digital technologies that can enable smart and sustainable urbanization, as well as the promotion of sustainable transportation and infrastructure.

12. SDG 12: Responsible Consumption and Production: This SDG is closely linked to the green transition, as it focuses on promoting sustainable consumption and production patterns. Achieving this goal requires the optimization of resource use, the reduction of waste and emissions, and the promotion of sustainable production practices.

13. SDG 13: Climate Action: This SDG is directly related to the green transition, as it focuses on taking urgent action to combat climate change and its impacts. Achieving this goal requires the reduction of greenhouse gas emissions and the promotion of renewable energy sources.

14. SDG14: Life Below Water: The promotion of sustainable fishing practices and reduction of marine pollution can support the conservation of marine biodiversity and ensure the sustainability of marine resources. The use of digital technologies to monitor and manage marine resources, support sustainable fishing practices and reduce marine pollution.

15. SDG 15: Life on Land: The promotion of sustainable land use practices that supports the conservation of biodiversity and natural ecosystems including the reduction of deforestation, land degradation and soil erosion makes this SDG related to the green transition. Digital transformation is related to the use of digital technologies to support the monitoring and management of natural resources including the promotion of sustainable agriculture and the restoration of degraded ecosystems.

16. SDG 16: Peace, Justice and Strong Institutions. Digital technology has been documented to promote transparency, accountability and participative governance. This would also provide avenues for the effective implementation of policies related to green transition.

17. SDG 17: Partnerships for the Goals: This SDG is relevant to both the digital transformation and green transition, as it focuses on strengthening partnerships to achieve sustainable development. Achieving this goal requires collaboration between stakeholders, including governments, civil society, and the private sector, to support the deployment of digital technologies and sustainable practices.

Source: Author's compilation

Digital transformation, initially aimed at boosting economic competitiveness, is now recognized for its role in SDGs and supporting a sustainable green transition. The merging of green and digital shifts, with technologies like AI and IoT, is seen as mutually beneficial. These technologies promise to enhance green efficiency, reduce carbon footprints, introduce new green technologies and circular economy models, but also pose environmental risks due to resource use and energy consumption. (Lema and Rabelloti 2023)

There are concerns that the twin transition may deepen and widen inequalities along gender and spatial divides.

Along gender lines, evidence indicates that female work has a high risk of being automated (see, for example, Brussevich et al. 2019). The atomization of work through digital labor platforms has benefitted both men and women, although a nuanced look indicates disparities. Jobs on digital platforms follow gendered patterns observed in non-platform work arrangements. More women are on platforms specializing in routine tasks (Ross et al. 2010; Kuek et al. 2015). More women are into clerical and support services, while more men are into STEM and IT jobs (Barzilay and Ben-David 2017; Churchill and Craig 2019). As a result of digitalization, clerical roles, cashiers and ticket clerks, and data entry clerks are expected to have the fastest declining roles in the workplace (WEF 2023). In the Philippines, around 60% of these workers are women[7]. In addition, uneven access to connectivity drives urban-rural inequalities in harnessing the benefits of digitalization. The move towards smart city development will likely magnify this digital-spatial divide, with heavy investments pouring into these sites and little investments in the countryside.

On green transformation, concerns are raised that the green transformation may be biased toward sectors where women are historically underrepresented. These concerns are tenable given that evidence (see ILO 2012) indicates that key sectors, including agriculture, forestry, fishing, energy, resource-intensive manufacturing, recycling, buildings, and transport, will transform more than others. Many men are engaged in extractive industries, energy, transportation, and construction. Thus, employment will decline in mining/quarrying but will increase in other sectors as efficient energy use, clean transportation, and green buildings become mainstream. More women and children are engaged in waste management and recycling, currently, jobs mostly informal and low pay. A substantial number of women are also

[7] Based on LFS July round 2016, 2017, 2018, and 2020.

observed in agriculture, but they are performing lighter tasks. Even for similar manual tasks in the agricultural sector, evidence of the gender pay gap favoring men was observed in the Philippines (Briones 2018).

Gendered disparities are also observed in the country's STEM enrollments and Engineering graduates in the country. Based on the PSA data in the academic year 2014-2015, the share of female enrollment in STEM courses was 37%. Meanwhile, the share of female graduates in Engineering in 2018 was 24.5% (Bello 2023). These disparities can substantially affect women's labor market prospects as the country advances its twin agenda. Cleaner energy and more efficient resource use require innovations in technology and engineering. Smart systems like smart cities and smart grids require big data analytics. Thus, how these existing inequalities will deepen in the green economy is a valid issue if sustainable and equitable development is to be achieved.

Another concern is that the twin transition's demand for skills and talent will outpace supply. This dual transformation is the key driver of job destruction, creation, complementation, and transformation. In the digital front, the fastest growing roles are AI and machine learning, and in the green economy, Sustainability Specialists and Renewable Energy Engineers (WEF 2023). However, as jobs are created due to the transition, available talents are not enough to take on new roles. This can inhibit the full transformation of economies, especially because the intersection of digital jobs in green economies is becoming clear. ADB and LinkedIn (2022) find that digital skills like visualizing and interpreting data are critical to energy forecasting and engineering innovations for clean energy. The same document finds that digital talents in e-learning and smart cities are 75% and 70%, respectively.

3.3. Remaining questions to ensure the dual transformation supports the achievement of a sustainable future in the Philippines

3.3.1 What might be the impact on production and trade of local industries?

For developing countries, the dual transformation of green transition and digitalization involves accelerating a process of industrialization that would normally take decades so industries are now undergoing these two transformations in parallel (Ezzat 2023). Digitalization entails businesses using digital technology (data, cloud, Artificial intelligence, internet of things, edge computing) for all aspects of business process – from product development, production, operations, sales and even materials recovery. Meanwhile, green transition entails designing, building, and scaling products and operations so that these become more efficient, more sustainable, and more resilient. Sustainable design or circular practices not only reduce a product's environmental footprint but also improves the resource-use efficiency, making manufacturers more resilient to supply chain shocks.

The intersection of digitalization and green transition is resulting in opportunities for servicification as well. E-invoicing and two-way communication platforms have customized services to meet unique customer needs, encouraging more conservation. Smart water metering has enhanced water infrastructure, aiding in mitigating droughts and shortages.

In terms of trade, the dual transformation may disrupt international value chains in four stages. First, it will lead to new patterns of consumer behavior, demand preferences and change consumption patterns. This will also lead to changing the demand for less resource-intensive and more environmentally friendly products and services. Second, these changes in

consumption would be enforced in the value chain through various types of new designs, standards, and specifications. Third, changes in the governance regime of the GVCs will create green entry barriers and green windows of opportunities. On the one hand, green entry barriers are created because greening governance may create constraints for suppliers in GVCs, making participation harder or forcing exits. On the other hand, windows of opportunities exist for certain suppliers who can develop sustainability capabilities leveraging them to their advantage. Finally, firms would undergo various innovations to reduce ecological footprint. Thus, the impact of the twin transition to firms would depend on their location in the GVCs.

Another aspect that needs to be addressed is digital trade and servicification. Digital trade and servicification have reshaped international trade and created opportunities for greater trade participation and firm growth. Incorporating services could enhance the productivity levels of manufacturing firms, as they could utilize services to increase the value of their products and gain access to new technologies and production processes (National Board of Trade 2016). Digital platforms such as online marketplaces have enabled more firms to participate in digital trade, mainly through cross-border e-commerce, as search communication costs are reduced, and e-payment systems provide easy and secure money transfers (ADB 2021).

Given this, digital platforms and servicification[8], which have been important factors in facilitating global value chains (GVCs) through an intensified flow of intermediate inputs across different GVC segments (Ladrière et al. 2020; Baldwin et al. 2021), would also be affected by the dual transformation. One direct impact would be the development of new tasks related to green transition facilitated by digital technology. Digital platforms have become another governance avenue (aside from lead firms in GVCs) that have the capability of facilitating the greening of firms and their production processes.

3.3.2 What would be the impact of dual transition to investment?

The twin transition requires the further strengthening of the avenues for funding green technologies particularly the renewable energy projects. The early stages of most renewable energy projects involve substantial costs, with limited local financing available. To address this, local banks like the Land Bank of the Philippines and the Development Bank of the Philippines have devised special packages to assist developers during this phase. The debt capital market, especially green bonds, offers another financing avenue, suitable for large projects or portfolios, with various structuring options like project bonds and ABS (Davidson et al. 2020).

The country has multiple instances of green bond issuances for renewable projects. Notable examples include AboitizPower's 2016 green bond for its geothermal project, supported by ADB, and BDO Unibank's 2017 green bond for financing multiple renewable projects. AC Energy has been active in green bond issuances, with a significant 2019 issuance for regional projects. Similarly, Chinabank's 2018 green bond focused on various climate-smart initiatives.

Renewable energy funding in the Philippines is diverse, ranging from bank loans to green bonds in capital markets. This variety supports both large-scale and innovative greenfield

[8] The emergence of GVCs has also been closely linked with services, as firms were able to leverage advancements in transportation and communications to divide their production processes across geographical locations and sectors.

projects. Smaller projects can leverage funding through securitization or green loans, while local governments might aggregate debt for lower-cost green financing.

ADB released a report green opportunities for the Philippines. The report lists a number of projects with varying stages of completion. Table 1 presents the projects that have been completed and are operational. In Total, USD 6.3B have already been invested for the completion of these projects.

While the Philippine experience in the rise of investment in green energy and green infrastructure is laudable, Gigler (2020) also raises the issue of the presence of the investment gap for clean climate technologies. The venture capital funding for climate technologies have been declining since 2011. Renewable energy startups founded in the Silicon Valley have shut down and a mere 2.5%~6% of US venture capital funding is going to climate technologies.

Table 1. Completed green projects in the Philippines

Sector	Project name	Cost (USD)	Greenness	Pipeline source
Transport	Light Rail Transit line 3 (MRT3)	655M	Green	PPP Center
Transport	Southwest Its project	51.5M	Green	PPP Center
Transport	Automatic Fare collection system	35M	Green	PPP Center
Hydro power	Bakun A/B and C Hydroelectric power plant	83M	Potentially green	PPP Center
Sustainable water management	Bulacan Bulc Water supply project	502.6M	Potentially green	PPP Center
Sustainable water management	Clark Water supply and sewerage project	4.9B	Potentially green	PPP Center
Sustainable water management	Subic Water and sewerage project	120M	Potentially green	PPP Center

Source: Green Infrastructure Investment Opportunities Philippines 2020 Report

Other projects in renewable energy involve solar energy, hydropower and wind. In 2018, the Board of Investment approved eight solar projects worth USD1.65 billion through the Solar Philippines Commercial Rooftop projects inc. The enormous scale of investment is projected to lower cost of electricity and trigger additional investments. The government is also exploring potential sites for hydropower. In 2019, more than 50 wind projects registered with the department of energy.

3.3.3 How will the dual transformation affect work?

In the Philippines, the dual transition is also occurring at different phases. Digitalization has more traction in the country since it dovetails with the Fourth Industrial Revolution and the significant advancements in information and communications technology. Thus, plans and programs are in place to support digital transformation (see Bayudan-Dacuycuy and Serafica 2023; Serafica and Oren 2023 for a more comprehensive list). For example, the DICT identifies strategies to improve the broadband environment through its National Broadband Plan and Connect, Harness, Innovate, and Protect (CHIP) strategic framework and provides access to underserved communities through the Technology for Education, Employment, Entrepreneurs, and Economic Development (Tech4ED) Project. Focusing on enterprises, the DTI promotes e-commerce through its E-Commerce Philippines 2022 Roadmap and various skills and training development services for entrepreneurs. TESDA and DOST also have their initiatives, including the Go Digital ASEAN and the League of Developers Initiative (LODI) project, respectively. Digitalization of public services is also underway. Paspas Pilipinas Paspas project, a collaboration of various government agencies, is a key step to implementing the Ease of Doing Business Act through the electronic business one-stop shops (eBOSS) in LGUs.

Despite digitalization being heavily embedded in the blueprints, roadmaps, and legislative agenda, much remains to be hurdled in infrastructures, including poor digital infrastructures, expensive ICT, and few secured internet servers, and in human resources, including the lack of skills and low digital adaptability (Bayudan-Dacuycuy and Serafica 2023). Indeed, evidence indicates that around 25% of Filipino online workers are into clerical and data services (at least15 percentage points higher than other Asian countries), and around 14% are into software development and technology (at least 31 percentage points lower than other Asian countries) (Bayudan-Dacuycuy et al. 2020). ADB and LinkedIn (2023) also reported disparities in digital skills in Asia, with India and Singapore demonstrating expertise in advanced and intermediate programming skills and Indonesia, Malaysia, and the Philippines demonstrating digital literacy and skills for graphic design.

Meanwhile, the concept of a green economy and green jobs is relatively nascent. The Green Jobs Act (RA 10771) in 2016 is the legal basis to promote and protect workers under a green economy. Based on its Implementing Rules and Regulations, fiscal incentives and assistance programs will be provided to enterprises to generate and sustain green jobs. Government agencies like the DepEd, CHED, TESDA, DOST, and PRC are mandated to promote skills and curriculum development aligned with the green agenda. TESDA has integrated green competencies in some of its curriculum and training, although only 20 training regulations (around 7.5% of the total TRs) have green competencies (TESDA 2018). TESDA (2018) acknowledges several challenges in greening TVET, including inadequacies in personnel's skills (i.e., lack of knowledge on greening, lack of research capability, inability to anticipate green skills), human resources (i.e., lack of green champion, experts on greening training regulations, curricula, and learning materials), and lack of standards and monitoring and evaluation framework. Meanwhile, the National Green Jobs Human Resource Development Plan 2020-2030 outlines strategic action plans to promote green jobs in the following areas: awareness campaigns, education and skills development, employment facilitation, productive workplace, social protection, industry resilience, green financing, and policy coherence.

The shift towards low-carbon, environmentally friendly economic growth has been pushed earlier but has gained traction in the discourses about the world of work only in recent years. The push was made at the first global UN Conference on Human Environment in 1972 when

the then ILO Director-General called for comprehensive environmental policies amidst growth and innovation (van der Ree 2017). However, it took almost two decades before environmental challenges in the world of work figured into serious discourses. This is due to the perceived incompatibility of environmental protection and economic growth. Fossil fuel is the engine of every nation's economic growth. Unfortunately, carbon emissions contribute to global warming and climate change. With fears of workers' displacement and economic slowdown, developing economies, whose emissions are smaller than developed nations, find it unfair to commit to lowering their fossil fuel consumption. Thus, initiatives to reduce these emissions, often facing opposition, are not at the top of funding priorities. For example, in 2013, funding for environmental sustainability was substantially lower than for industry, innovation, and infrastructure (less than US$ 25 billion versus US$ 147 billion, respectively) (UNESCO 2021). However, the adverse implications of climate change for agricultural yields and food security (see, for example, Burgess et al. 2011) and of global warming for job quality and productivity (see, for example, UNDP 2016) have renewed calls on environmental agenda.

One of the biggest challenge to achieving the green transition and digital transformation is the lack of skilled green workers (LinkedIn 2023; Lema and Rabelloti 2023). A scoping of the labor market conducted by LinkedIn (2023) analyzed the current trajectory of green skills[9] growth in the labor market and found that the human capital need to meet sustainability targets are insufficient. Although the number of workers moving into green and greening jobs exceeds those leaving, the overall count of transitioning workers remains quite low.

The transition to a greener economy and the increased use of digital technologies will require new skill sets and competencies which are currently in short supply in developing countries. Examples of skill sets and competencies related to the dual transformation include digital literacy, data analysis, understanding of renewable energy, sustainable design, project management, adaptability, communication skills and green entrepreneurship (LinkedIn 2023).

How the green transition will result in the loss of jobs in the "non-green" (also called brown) activities is also a major concern. Workers engaged in fossil fuel extraction, production of single use plastics and high GHG-emitting industries are particularly at risk as they are the first ones affected by climate policies and regulations. Workers and trainees in other sectors will be affected eventually as the whole economy's decarbonization expands (Linkedin 2023).

Globally, nations face challenges in adapting labor market skills for the green transition and digital transformation. New technologies in green energy and sustainability necessitate new and updated skills due to evolving professions. Education and training systems must reform to equip everyone with necessary skills for these societal changes. Additionally, specific measures are required to make green and digital transition opportunities accessible to women, youth, and other potentially marginalized workers.

[9] Green skills facilitate the environmental sustainability of economic sectors, whereas green jobs necessitate comprehensive green skills knowledge. Jobs that are greening may not always require green skills, yet often benefit from some level of these skills. On the other hand, jobs with greening potential occasionally need green skills but can generally be done without them. Non-green jobs, in contrast, do not require green skills. Green talent refers to LinkedIn members who have specifically included green skills in their profiles or are employed in green or greening roles.

3.3.4 What is the role of science, technology, and innovation?

For this dual transformation to support the achievement of a sustainable future, countries will need to raise their commitment to science, technology and innovation including research and development (R&D). Recent UNESCO figures show that advanced economies dominate research spending, number of researchers, and R&D outputs such as publications and patents. Despite increased research expenditure in many regions from 2014 to 2018, 80% of countries invest less than 1% of GDP in R&D. With researcher numbers growing faster relative to expenditure in some areas, less funding becomes available to each researcher. (UNESCO n.d.; UNCTAD 2022).

Science, Technology and innovation are important in the development of smart cities as technology and innovation are woven into the regular operations of a city. Smart cities leverage digital technologies for better urban management. This includes IoT (Internet of Things) devices, big data analytics, AI, and other digital tools to improve city services, infrastructure management, and citizen engagement. These technologies enable more efficient resource management, better traffic control, enhanced public safety, and improved quality of life. Smart cities prioritize sustainability and environmental stewardship. Smart cities also require innovation in features like green buildings, sustainable transport systems, and urban green spaces which contribute to reduced carbon footprints and enhanced environmental health.

For the Philippines, the development of smart cities is underway in the Philippines and requires digital competencies in processing, monitoring, and communicating information culled from big data (Ballesteros and Ancheta forthcoming). Currently, the lack of skilled IT personnel who will manage and maintain smart systems is a binding constraint. Indeed, based on the DOLE's Labor Market Information Report 2017-2022, Data Scientists and Researchers (on Big Data) are both in-demand and hard-to-fill jobs. These are jobs advertised repeatedly by industries but unfilled for a period of time due to the lack of qualified applicants.

3.4. What is the role of Artificial intelligence in a world of dual transformation?

The increasing use of AI and other advanced technologies presents both opportunities and challenges. While AI has the potential to revolutionize many industries and improve efficiency, it also raises concerns about job displacement, privacy, and ethical use of data.

Artificial Intelligence (AI) is expected to have the most significant impact of all the Fourth Industrial Revolution technologies. Considered a general-purpose technology, AI will not only affect all industries in the economy but will increasingly influence everyday life (ITIF 2018; PWC 2018; Statista 2023). See Table for various descriptions of AI.

Table 2. Various definitions of Artificial Intelligence

A branch of computer science devoted to creating computer systems that perform tasks characteristic of human intelligence, such as learning and decision-making. AI overlaps with other areas of study, including robotics, natural language processing, and computer vision. ITIF (2018 p.1)
The ability of machines and systems to acquire and apply knowledge, and to carry out intelligent behavior. This includes a variety of cognitive tasks (e.g., sensing, processing oral language, reasoning, learning, making decisions) and demonstrating an ability to move and manipulate objects accordingly. Intelligent systems use a combination of big data analytics, cloud computing, machine-to-machine communication and the Internet of Things (IoT) to operate and learn. ESCAP (2017, p.1)
AI is a term for computer systems that can sense their environment, think, learn, and act, in response to what they sense, and their programmed objectives. PWC (2018, p. 3)
An interdisciplinary branch of computer science, AI focuses on developing intelligent systems and machines that can solve complex problems, specifically those that typically require human intelligence. Statista (2023, p.8)

Source: Authors' compilation

In the last decade the functionality of AI has improved significantly with advanced hardware, increasingly powerful computing capacity, the availability of massive amounts of data for training AI models, and more sophisticated algorithms and software enabling the development of many new applications (ESCAP 2017). Given its sophisticated functionalities, AI can predict and provide personalized recommendations, discover new solutions through simulations, and facilitate interactions between humans, computer systems, and objects as well as coordinate machine-to-machine interactions (ITIF 2018). AI allows systems to interact with humans in a conversational manner and is being employed in a variety of industries. In financial services, AI is used to automate customer support, provide personalized recommendations, and detect fraud in financial transactions (Statista 2023).

3.4.1 Contributing to the green agenda

Digital technologies can accelerate the green transition in various ways (Muench et al. 2022): (i) **Monitoring and tracking –** digital technologies facilitate the monitoring of material flows, emissions, and the condition of the environment by providing accurate and real-time data. Such tracking system is critical to the operation of a circular economy involving the recycling and reuse of materials; (ii) **Simulation and forecasting –** digital simulations can enhance efficiency by providing information about the life cycle of a product or process which improves reparability and upgradability. Weather or electricity demand forecasting aids in preparing for crisis events; (iii) **Virtualisation** – reduces the environmental impact of industries with digital alternatives (e.g., ebooks) or by moving certain economic activities online (e.g., meetings via videoconferences, e-commerce, online events). To be consistent with the green transition, the digital technologies that are utilized must be both energy-efficient and circular; (iv) **Systems management -** by combining various digital technologies systems management can cope with increasing complexity while at the same optimizing operations**,** for example, in smart cities, smart electricity grids, and smart manufacturing; and (v) **Enabling new levels of interaction –** various information and communication technologies not only facilitate data collection and dissemination but also create new levels of interaction. For example, the environmental

footprint of a product can be determined from smart packaging and labeling while digital platforms act as intermediaries between buyers and sellers.

PWC (2018) examined the application of AI for SDGs related to the environment which include, among others, fighting climate change, proper use of ocean and marine resources, developing smart and sustainable cities, and making available clean affordable energy. A review of more than 80 existing AI use cases indicates that the majority were powered by **automated** as well as **assisted** intelligences systems, to gain insights and extract value from massive amounts of unstructured real-time data. The report notes that more applications using **autonomous** AI will likely emerge, providing more opportunities as well as threats.

AI can enable the achievement of the SDGs and specifically, in addressing environmental challenges. Vinuesa et al. (2020) examine how AI can help or hinder the achievement of the 17 goals and 169 targets identified in the 2030 Agenda for Sustainable Development. In their study, AI is defined as "any software technology with at least one of the following capabilities: perception—including audio, visual, textual, and tactile (e.g., face recognition), decision-making (e.g., medical diagnosis systems), prediction (e.g., weather forecast), automatic knowledge extraction and pattern recognition from data (e.g., discovery of fake news circles in social media), interactive communication (e.g., social robots or chat bots), and logical reasoning (e.g., theory development from premises)" (pp. 1-2). Following a consensus-based expert elicitation process, they find that while the achievement of 134 targets can be facilitated using AI, 59 targets can be inhibited by AI. For the environment-specific goals, which include Goals 13 (Climate action), 14 (Life below water), and 15 (Life on land), 25 targets (or 93% of the targets) could be achieved using AI. The benefits of AI are largely due to its ability to analyze large-scale interconnected databases that can help develop joint actions to protect the environment.

3.4.2 Risks and challenges of AI

Van Wynsberghe (2021) argues that while AI can address environmental problems such as those identified in the SDGs, the sustainability of AI itself must be examined. The benefits of using AI for sustainability must be weighed against the cost by quantifying the environmental impact of generating and using AI models, such as carbon footprints and the amount of processing power required to train algorithms. Vinuesa et al (2020) noted that the high energy requirements of AI applications could undermine climate action especially if the energy sources used are not carbon neutral. Also problematic is the possibility that increasing access to AI-related information of ecosystems could lead to increased exploitation of natural resources. There is also the potential tension between the need for vast amounts of detailed information to enhance AI algorithms versus more transparent handling and protection of personal data. Biases that exist in the data used to train AI models could also worsen discriminatory practices. At the global level, the uneven distribution of computer and educational resources might exacerbate economic inequalities. See Table 3 for examples of various AI-related risks by category.

Table 3. Artificial Intelligence risks by category

Types of risks	Examples
Performance risks	Risk of errors; Risk of bias; Risk of opaqueness or "black box" risk; Risk of explainability; Risk of stability of performance
Security risks	Cyber intrusion risks, Privacy risks, Open-source software risks
Control risks	Risks of AI going "rogue"; Inability to control malevolent AI
Ethical risks	"Lack of values" risks; Value alignment risk; Goal alignment risk
Economic risks	Job-displacement risks; "Winner-takes-all" concentration of power risk; Liability risk; Reputation risk
Societal risks	Risk of autonomous weapons proliferation; Risk of "intelligence divide"

Source: PWC (2018, p. 23)

AI and other new technologies risk the widening of the gap between rich and poor countries by shifting more investment to advanced economies where automation is already established.

Recent article by the Economist (2023) shows that 80 percent of Americans could have at least 10 percent of their work tasks done by AI tools. For some workers, as much as 50 percent of their work tasks can be accomplished without loss in quality by AI tools. These workers belong to the industries which heavily rely on programming and writing skills such as legal services, financial and insurance services. Telemarketers could be made redundant as well which teachers especially those in languages, history and literature are next in line. There is however some glimmer of hope as jobs that need essential human qualities such as empathy and charisma have been overlooked by these studies. AI tools will also need handlers which may end up creating new jobs.

To help ensure sustainable development and prevent gaps in ethical standards, transparency, and safety, Vinuesa et al (2020) stressed the need for regulatory insight and oversight. They add that insight must precede oversight, as policymakers must have sufficient understanding of the challenges of AI before formulating policies to ensure these will be effective and are not counterproductive.

4. Strategies for the twin transition

4.1 Dual transformation strategies in the Philippine Development Plan 2023-2028

Recognizing the emerging global and regional trends pushing the Philippines towards this dual transformation, The PDP has identified strategies related to this dual transformation.
The 2023-2028 Philippine Development Plan recognizes the environmental forces and digital trends as factors shaping the future of the Philippines. To this end, the underlying theme of "transformation" has been adopted by the PDP. Strategies related to digitalization and green transition of production sectors have been identified in the various chapters of the PDP 2023-2028.

For the production sectors, farms utilizing modern technologies such as location-specific, sensor-based, and precision agriculture; smart greenhouses; and controlled environment agricultural techniques will be promoted. Farmers are also encouraged to use mobile platforms and channels for marketing, payment, and product delivery of agricultural and fish products. Businesses will be co-located with other industries, service enterprises, and academic institutions, to promote the adoption of Industry 4.0 technologies. Businesses will also be encouraged to develop green technologies and establish facilities for waste recovery, reuse and recycling.

Communities are also encouraged to adapt to the dual transformation. One strategy is the adoption of green features in housing and community design, such as renewable energy, green roofs, rainwater harvesting systems, rain gardens, permeable pavement, green construction materials, nature-based storm drainage systems, gray water recycling system, and energy-efficient windows (with reference to the Green Building Code). Construction companies are also encouraged to conduct R&D to adopt green architecture and additive manufacturing which would reduce production cost.

Strategies related to labor and employment include the government creating a database of green jobs, implementing the Green Jobs Human Resource Development Plan, and intensifying the integration and mainstreaming of green competencies in TVET and education programs.

4.2 Other government plans for green transition

Aside from the PDP, other government documents have also acknowledged role of technology in the green transition. The Pagtanaw 2050 ("looking ahead") is the first interdisciplinary initiative focused on Philippine Science, Technology and Innovation foresight. The government document aims to create a strategic roadmap by proactively identifying the variables that will shape the growth of scientific advancements in the Philippines leading up to 2050 (NAST 2021). The plan has identified specific technologies for the Environment and Climate Change operational area. Many other technologies were identified in related operation areas (See Appendix for a list of the technologies).

The National Economic Development Authority has promulgated the National Innovation Agenda and Strategy Document (NIASD), which outlines the nation's vision and long-term objectives for innovation. Additionally, it provides strategies for enhancing innovation governance, intensifying and accelerating innovation initiatives, and focuses on the integration and cultivation of public-private partnerships. The National Innovation Agenda Framework notes that having an efficient, clean, and sustainable environment is one of the key pillars to achieving a smart and innovative country. To this end, the government aims to support the development of innovative products and processes towards ensuring that natural resources are used sustainably for optimum productivity levels (NIASD 2023).

Other sector-specific plans developed by national government agencies promote the use of innovation to achieve sustainable goals of their industries. The Department of Energy in its Philippine Energy Plan 2018-2040 stipulates the promotion of an innovation culture to support emerging renewable technologies and business models (PEP 2018-2040). In addition, the Philippine Export Development Plan 2023-2028 recognizes that to develop the Philippines as an agile export powerhouse in key industries, it must develop, among others, exporters that are technology-driven and sustainable. Technology is a critical for companies to stay ahead of emerging trends and remain competitive in the global market. The plan also promotes the adoption of sustainable business practices to minimize the degradation of the environment. Among key areas, the plan identifies the important role of digitalization and sustainability in agricultural and agri-based exports (PEDP 2023-2028, 2023). In 2017, the Department of Information and Communications Technology published the National Broadband Plan, a blueprint to expedite the deployment of fiber optic cables and wireless technologies, ultimately enhancing the country's Internet speed.

Several plans have also been developed by national government agencies to create a globally competitive workforce. The Department of Labor and Employment has formulated the Labor and Employment Plan (LEP) 2023-2028. Among its three focal areas, the plan aims to increase employability and promotes sustainable and resilient enterprises among micro, small, and medium enterprises. Additionally, the National Technical Education and Skills Development Plan (NTESDP) 2023-2028 serves as the national blueprint for the technical vocational education and training (TVET) sector. The plan focuses on digitalization in response to the Fourth Industrial Revolution and shall collaborate with priority sectors such as Manufacturing, Transportation & Logistics, Health, IT-BPM, Creative Industries, Energy, and Construction (TESDA 2023).

5. Conclusion and Recommendations

The emergence of twin transformation, signifying the simultaneous development of technological and environmental factors, has inaugurated a new era in policy formulation. This dual process presents policymakers with distinct challenges and prospects. The rapid advancement of technology, alongside the pressing need to address environmental issues, requires policy frameworks that are not only flexible but also comprehensive. Policymakers face the intricate task of balancing the promotion of innovation with the management of environmental impact. This complexity necessitates policies that not only promote sustainable technological progress but also provide a unified approach to mitigate ecological consequences.

Implementing a whole-of-government approach is crucial when formulating policies to tackle twin transformation. The simultaneous evolution of technological and environmental factors demands a comprehensive and integrated response from various government agencies and local government units. By pooling expertise and resources across government departments, policymakers can develop strategies that address the dual dynamics of technological innovation and environmental sustainability in a coordinated and synergistic manner. This approach not only promotes policy coherence but also enhances the government's ability to respond effectively to the interconnected challenges of our time, creating a more sustainable and resilient path forward.

Governments must critically assess their current position in the implementation of twin transformation to effectively navigate the complex challenges presented by this dual evolution of technology and environmental concerns. This assessment serves as a crucial benchmark, providing insights into the progress made, identifying gaps, and highlighting areas that require immediate attention. By conducting a comprehensive evaluation, policymakers can discern whether existing policies align with the goals of twin transformation or if adjustments are necessary. Moreover, such an assessment enables governments to gauge their capacity for innovation, environmental sustainability, and the integration of these efforts into policy frameworks. Understanding their standing in the realm of twin transformation empowers governments to make informed decisions, reallocate resources strategically, and implement targeted initiatives.

Policy Implications

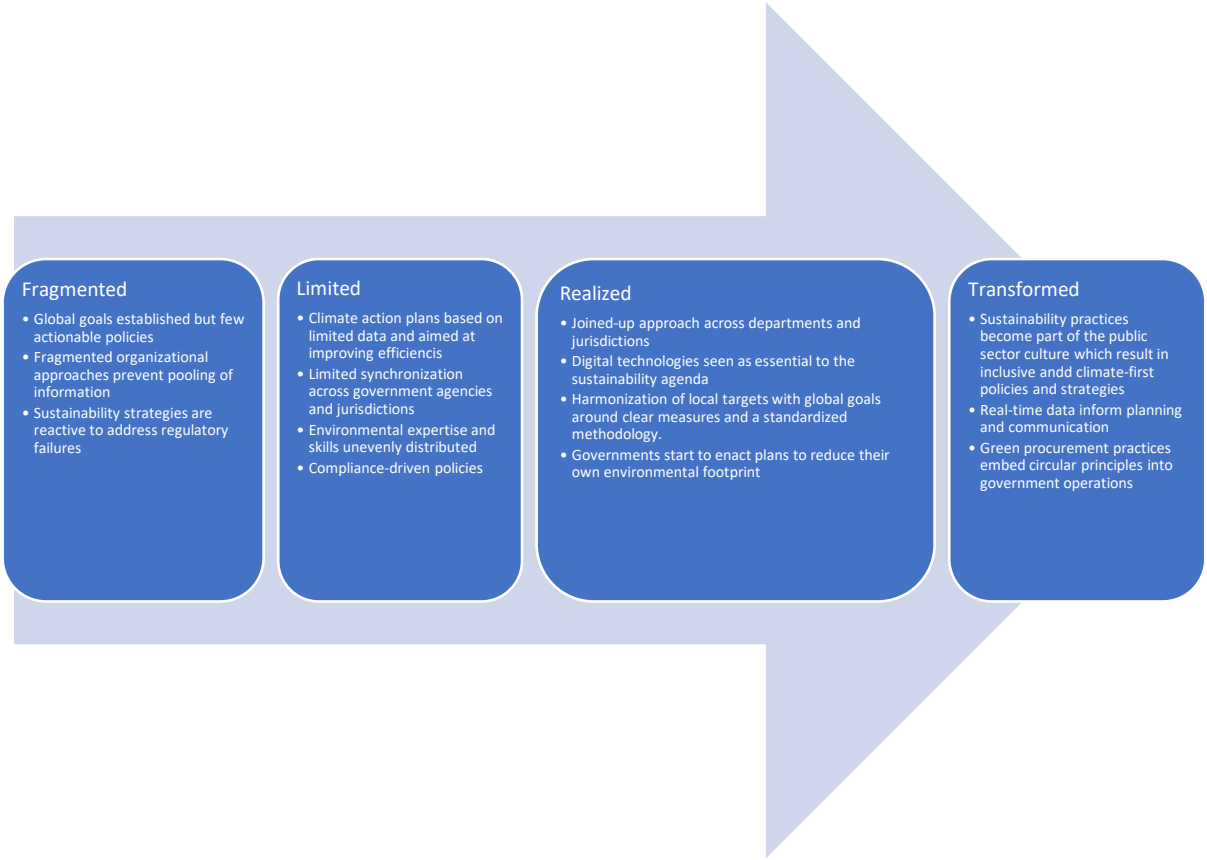
Government should assess itself and understand its role in this dual transformation. One of the key functions of government is to ensure that the public sector perceives the dual transformation not as mutually exclusive events (Gigler 2020; Microsoft 2023) to ensure that progress can be achieved on both fronts. It would also allow cross-government synergies addressing also issues of equity. Microsoft (2023) has identified a diagnostic framework to describe the progress of governments and economies in their dual transition (Figure 1).

The framework has four stages. The first stage is “Fragmented” which is characterized by governments setting ambitious targets aligned with SDGs and Paris Climate agreement. However, detailed plans have not been laid out and Standardization for integrating climate and environmental risks into strategic planning is lacking, with government action focusing more on regulatory failures and disaster response than proactive resilience planning. Policies are often in early stages, with unclear implementation paths. Leaders are generally unaware of their organization's environmental impact and how to use digital technology for sustainability challenges (Microsoft 2023).

The second stage is “Limited”. This is characterized by governments progressing in sustainability targets, yet innovation is fragmented with isolated areas of excellence rather than holistic planning. Some are considering unified sustainability definitions and resources, with a few establishing climate and sustainability units to fill gaps. Leaders promote digital methods but lack clear tactical plans and have limited insight into their operations' climate impact (Microsoft 2023).

The third stage is “Realized”. Some governments have aimed to reach this phase during the recovery from the COVID-19 pandemic as strategies for inclusive recovery are both related to the clean transition and to the digital transformation At this stage, governments adopt a unified sustainability strategy, connecting various agencies and linking central with local governments. Top leaders advocate for digital technologies in sustainable development strategies, and efforts to assess the government's own environmental impact start taking shape.
The final stage is the “Transformed”. This is characterized by governments integrating sustainability into their departments, fostering a culture of eco-consciousness in their services and among stakeholders. This leads to policy-making that prioritizes inclusivity and climate concerns. Senior leaders actively participate in planning and implementing green technologies, emphasizing the advantages and vision for the government's sustainability path. To exemplify this commitment, governments adopt measures to mitigate the environmental effects of their operations.

Figure 2. Stages of dual transition



Source: Lifted in full from Microsoft (2023)

Create and strengthen the protection and promotion of human capital development. Given that three out of the Philippine government's 8-point agenda are on jobs (more jobs, quality jobs, and green jobs), key players in the country need to create and strengthen the protection and promotion of human capital development.

Government: The government needs to prepare the workforce for disruptions through strategic investments in human capital, infrastructures, and research and development. Sectoral policies and resource use must be cohesive, working toward the vision of where the country will be in the long run and what needs to be done in the short- and medium-run should be in place. Thus, as a facilitator and driver of the dual transition, the government needs to:

- Identify strategic sectors where the country sees itself harnessing or developing its comparative advantage. Leverage the fiscal incentives in the Green Jobs Act to support the development of these sectors. Two important aspects to note, however. First, a skilled workforce to match the job creation is crucial. People who can assess, audit, and certify compliance are also needed to provide incentives. Thus, skills and training development programs that focus on strategic sectors are crucial. These can serve as building blocks for the skills development of non-key strategic sectors. Second, support and incentives should not be limited to firms that create jobs but should also include firms that integrate green processes into their businesses.
- Explore establishing a labor market information system that integrates existing information systems and planned skills initiatives. Currently, skills initiatives and information systems are sectoral-led. These include the TESDA's Registry of Certified Workers (https://www.tesda.gov.ph/Rwac) and DOLE's job matching portal and labor market information (https://philjobnet.gov.ph/). Meanwhile, the DOLE's National

Green Jobs Human Resource Development Plan 2020-2030 aims to develop a national registry of all green jobs in the country by launching the Career Information System (CIS). The National Technical Education and Skills Development Plan 2023-2028, the TVET's roadmap, is currently being developed and will likely include digital and green skills. The DTI's Philippine Skills Framework Initiative develops sector-specific and cross-sectoral skills frameworks to guide employers and training providers in their talent development plans. Its priority sectors include Logistics and Supply Chain, Creatives, Construction, Manufacturing, Health and Wellness, IT-BPM, Tourism, and Food Agriculture (https://innovate.dti.gov.ph/resources/ph-skills-framework/). These initiatives have overlaps and complementarities. Assessing how plans can build on one another or how initiatives can harness the synergy of various agencies will maximize the use of resources, bringing better services and outcomes coherent with the country's vision of sustainable development.

- Explore the establishment of a Commission on Skills and Lifelong Learning that will craft plans, spearhead research, and harmonize the country's skill and lifelong learning initiatives, including the integration of labor market, career, and skills information systems. Advanced programming/coding and big data analytics are already identified as requisites for automation and digitalization. These skills intersect with a green agenda, which involves innovations in engineering and technologies to manage smart systems like smart grids, smart agriculture, and smart cities. Currently, the country's digital skills portfolio enables workers to harness opportunities in clerical tasks and creative and multimedia services. How these skills can be upgraded to serve the country's vision of dual transition is a challenge that needs a longer-term planning horizon and the synergy of various agencies. Doing so will enable stakeholders like the academe, training institutions, and businesses to align their visions, goals, and action plans.
- Revise the Philippine Standard Occupation Codes (PSOC) to include digital and green occupations. Use the PSOC in the labor market and career information systems and skills framework initiatives. Currently, the 2012 PSOC does not identify green occupations, although green jobs can be extracted from its manual by looking at the occupation descriptions. For example, around 5% of the listed jobs in the PSOC manual have tasks related to the term "environment/environmental". However, new jobs are yet to be integrated into the occupation codes. For example, 35% of green jobs in O*NET, as listed in Peters (2014), are not in the PSOC (e.g., Green Marketers, Water Resource Specialists, Hazardous Materials Removal Workers, Hydroelectric Production Managers, Solar Energy Installation Managers, Solar Photovoltaic Installers, Energy Auditors). Green jobs identified by DOLE[10] are also yet to be reflected in the PSOC. It is crucial that the statistical system be updated to harmonize monitoring and planning activities and strengthen research capacities.
- Integrate affirmative action into strategic plans and agenda. Some segments of society will be more adversely affected by the digital and green economy. These can include the historically marginalized, such as women, persons with disabilities, and the Indigenous Peoples. Affirmative actions do not mean creating new or separate programs. Rather, these entail designing programs that account for disparities in access, exposure, and opportunity.

[10] See https://cip.philjobnet.gov.ph/?page_id=3189

- Expand social protection products and services. With or without the transition towards a digital and green economy, unemployment insurance (UI) must be in place, covering both formal and informal workers. A UI that covers training costs while workers are in between jobs is desirable. Encourage UI enrollments by offering various payment structures and payment channels and shortening the eligibility period.

Academe and training institutions: A successful transition to a digital and green economy requires a training system that quickly adjusts to the evolving skills needs of the labor market. Thus, the following are desirable:

- Improve the agility of higher education institutions (HEIs) in responding to the needs of the labor market and industry. The majority of the HEIs (around 95%) are regulated and need the CHED's approval when offering new courses/programs. Only 5% (autonomous universities) can do so without undergoing bureaucratic processes. Thus, the challenge of how the tertiary education sector can be more responsive to innovations and developments without sacrificing quality in education must be addressed.
- Leverage labor market information systems in developing programs/courses.
- Strengthen the TVET manpower. Commit resources to get the best practitioners abroad to train the trainers in the country. Send scholars abroad to learn about new technologies and best practices to transform the identified sectors. The shortage of competent practitioners who can help develop training regulations and curricula can stall any well-planned digital and green agenda.
- Strengthen partnerships of TVET institutions with firms and the industry. Active collaboration with these sectors enables the training system to become more responsive to changes in the needs of the labor market.

Firms: Firms have stakes in ensuring their workers have the correct skills. In the Philippines, there are efforts to provide digital skills training to their existing workforce (58%), but very few collaborate with external trainers (33%)[11]. To reskill/retool their existing workforce, firms can explore TESDA's enterprise-based training (EBT) programs. Firms can explore putting up necessary measures to recover their investments. Tap the EBT programs to obtain skilled workers.
To foster ownership, firms must be proactive in selecting participants and putting up the terms and conditions of the initiative.

Workers: Evidence indicates that employers see the complementation of traditional and digital credentials in the future (ADB and LinkedIn 2023). To enhance mobility, workers must be proactive in obtaining digital credentials (e.g., certificates for short-term courses, nanomasters).

Harness AI and other technologies to face the twin transition. The twin transition involves taking an integrated approach to the green and digital transitions so that synergies are exploited while managing the risks (Muench et al. 2022). The various technologies employed for the green and digital transitions have their respective environmental impacts. Research and innovation could reduce the resource footprint of the technologies over time. Regulation could also require or incentivize the adoption of more environmentally friendly technologies. The promotion of green-digital solutions, however, could have unintended consequences. For example, as a result of the switch to green products the prices of carbon-intensive products could decline making them more competitive, or housing space requirements could increase

[11] Based on the data in ADB and LinkedIn (2023).

due to teleworking. Rebound effects could be avoided by intensifying education and awareness about the environmental impacts of changes in consumer behavior (Muench et al. 2022).

On the various risks associated with AI, the government needs to be proactive in addressing the possible social, ethical, and environmental implications. Better governance, especially with respect to data and algorithms, is necessary to support an AI-enabled digital economy (PWC 2018). In addition to setting parameters for the use of AI, social and environmental principles and standards could be embedded in national digital programs and strategies. The government could also adopt a "responsible technology policy" to provide guidelines for innovators and ensure alignment with national and global commitments such as the SDGs (p. 27). To ensure that AI contributes to achieving all the SDGs, the development of rules and regulations must be driven by science (Vinuesa et al. 2020). At the same time, interdisciplinary collaboration and multi-stakeholder participation are essential in developing shared principles and governance frameworks, both national and global (Vinuesa et al. 2020, PWC 2018, UN ESCAP 2017).

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Appendix 1. Examples of countries adopting green transition in their development plans

Country	Location	Details of green economy plans/policies
Uzbekistan	Central Asia	Uzbekistan has identified priorities for the transition of the economy to a green development path and adopted the **Strategy for Transition of the Republic of Uzbekistan to a Green Economy for 2019-2030** (Resolution of the President of the Republic of Uzbekistan PP-4477 dated 04.10.2019) Source: Republic of Uzbekistan 2021
China	East Asia	According to the **14th Five-year Plan**, China will accelerate efforts to build and improve an economic structure conducive to green, low-carbon and circular development in its ongoing anti-pollution fight to achieve its carbon peak and neutrality goals. The plan targets that by 2025, the country would have reduced its energy consumption per unit of GDP by 13.5 percent from 2020 while keeping total energy consumption at reasonable levels. Source: https://english.www.gov.cn/
Japan	East Asia	Japan's **Clean Energy Strategy** aims for carbon neutrality by 2050 and a 46% reduction in greenhouse gas emissions by fiscal 2030. The plan has the following key components: Decarbonization and Energy Security (renewable energy and nuclear power), Green Transformation (GX), GX League and Hydrogen Focus. Source: https://www.japan.go.jp/
South Korea	East Asia	The **Korean New Deal: National Strategy for Great Transformation** released in July 2020 is based on two main policies: Digital New Deal and Green New Deal. To accelerate the achievement of a low carbon green economy, Korea allocates an investment of approximately $143 Billion for carbon reduction projects and creating 1.9 million green jobs by 2025. Source: https://english.moef.go.kr/pc/
Brunei Darussalam	South east Asia	Brunei Darussalam has implemented the **National Climate Change Policy** which incorporates ten key strategies aiming for 2035 as a general target year. This policy is pivotal in guiding the country's green transition efforts. A significant part of this strategy is to increase the total share of renewable energy to at least 30% of the total capacity in the power generation mix, focusing primarily on solar photovoltaic (PV) technology. This move indicates a strong commitment to reducing dependency on fossil fuels. Source: Climatechange.gov.bn
Cambodia	South east Asia	Cambodia has released several strategic plans for green growth, including the **National Strategic Plan on Green Growth 2013–2030, Cambodia Climate Change Strategic Plan 2014-2023,** and **the National Environment Strategy and Action Plan 2016–2023**. In addition, Cambodia has launched its **Long-term Strategy for Carbon Neutrality by 2050** which focuses on several key areas such as emphasizing the continuation of the Reducing Emissions from Deforestation and Forest Degradation (REDD+) Strategy, gradually decarbonizing the power and transport sectors while improving energy efficiency and promoting low-

Country	Location	Details of green economy plans/policies
		carbon approaches in agriculture, industrial processes, and waste management to reduce overall greenhouse gas emissions. Source: MOE
Indonesia	South east Asia	Indonesia's first-ever sustainable development plan, RPJMN 2020-2024 integrates low-carbon, green growth into Indonesia's national development strategy. Central to this strategy is the Low Carbon Development Initiative (LCDI) which aims to put low-carbon development at the core of Indonesia's development plan. It includes greenhouse gas emissions reduction as a key macro-economic indicator, aligning it with other crucial indicators like GDP growth, poverty reduction, and employment. This plan represents a shift in governmental perspective, moving away from viewing climate action and growth as trade-offs and towards recognizing the benefits of climate action. Source: https://www.wri.org/outcomes/indonesia-adopts-its-first-ever-sustainable-development-plan
Lao PDR	South east Asia	The **National Green Growth Strategy** of the Lao PDR focuses on: (1) encouraging and promoting the economic growth and poverty reduction in a comprehensive, inclusive and fair manner, allowing all persons in the society to receive the benefits from such development; (2) raising the efficiency and effectiveness of the utilisation of limited natural resources of the country to ensure optimal benefits; (3) economic growth that is clean and environmentally-friendly and that decreases wastes and greenhouse gas emissions; and (4) increasing the economic resilience to climate change, natural disasters and of global economic uncertainties. Source: UNEP
Malaysia	South east Asia	Malaysia implemented the **Green Technology Master Plan** to promote green technology adoption across various sectors, aiming for sustainable development by reducing carbon emissions and enhancing energy efficiency. In addition, the **National Energy Transition Roadmap** provides a sustainable energy pathway towards a high-value green economy. It includes initiatives and projects based on energy efficiency, renewable energy, and hydrogen, aiming for a 32% reduction in GHG emissions by 2050 compared to 2019 levels. Source: https://www.state.gov/; dfdl
Myanmar	South east Asia	**Myanmar Climate Change Strategy (2018 – 2030)** was formulated to address the challenges posed by climate change, considering Myanmar's vulnerability to climate-related events such as floods, cyclones, and droughts. This plan includes ecosystems-based adaptation and the implementation of nature-based solutions at the township level. An institutional structure was also established to coordinate national-level action on climate change. The plan also developed Myanmar's Intended Nationally Determined Contributions under the Paris Agreement. Source: UNEP
Philippines	South east Asia	Chapter 15 of the Philippine Development Plan specifically focuses on accelerating climate action and strengthening disaster resilience. This chapter sets the objective for communities, institutions, and both natural

Country	Location	Details of green economy plans/policies
		and built environments to become more resilient to the impacts of natural hazards and climate change by 2028. The strategies to achieve this include increasing climate and disaster risk resilience of communities and institutions, enhancing ecosystem resilience, and enabling transition to a low-carbon economy. Additionally, to support and operationalize the PDP 2023-2028, the Climate Change Commission (CCC) is updating the National Climate Change Action Plan (NCCAP) and the Nationally Determined Contribution (NDC), strengthening the implementation of the National Climate Risk Management Framework (NCRMF), and developing the National Adaptation Plan (NAP). These plans and frameworks provide a basis for working with relevant government agencies to enhance ecosystem resilience and enable a low-carbon economy transition. Source: https://pdp.neda.gov.ph/philippine-development-plan-2023-2028/#:~:text=Chapter%2015%3A%20
Singapore	South east Asia	The **Singapore Green Plan 2030** is a whole-of-nation movement to advance Singapore's sustainable development, aligning with the UN's 2030 Sustainable Development Agenda and the Paris Agreement. The plan's key targets include planting 1 million more trees, quadrupling solar energy deployment by 2025, and ensuring all newly registered cars are cleaner-energy models from 2030. The Green Plan comprises 5 pillars: City in Nature, Energy Reset, Sustainable Living, Green Economy, and Resilient Future.
Thailand	South east Asia	Thailand's latest development plan is the "Bio-Circular-Green Economy" (BCG) model, which focuses on sustainable growth and carbon emission reduction through technology and innovation, leveraging natural resources and cultural diversity. Key strategic sectors in the BCG Economy include agriculture and food, energy, materials and biochemicals, wellness and medicine, and tourism and the creative economy. The BCG plan includes ambitious goals like recycling 100% of certain plastics by 2030 and cutting food loss from 30% to 10%
Vietnam	South east Asia	National Strategy for Climate Change 2021-2030 envisions a significant reduction in emissions, with a goal to phase out coal power by the 2040s and achieve net-zero carbon emissions by 2050 Source: https://www.mckinsey.com/capabilities/sustainability/our-insights/charting-a-path-for-vietnam-to-achieve-its-net-zero-goals
Bangladesh	South Asia	The **Mujib Climate Prosperity Plan** has a strategic investment framework to mobilize financing, especially through international cooperation, for implementing renewable energy and climate resilience initiatives. The plan identifies several key initiatives, which focus in renewable energy, energy storage infrastructure, power grid modernization, Established carbon market regime, Bangladesh Delta Plan 2100 resilience bonds, training and skills development for future, Future-proof Bangladesh's industries, locally-led adaptation outcomes, Micro, Small and Medium Enterprise financial protection and productivity

Country	Location	Details of green economy plans/policies
		enhancement, Climate-Resilient and Nature-Based agricultural and fisheries development, environment friendly transport, climate resilient well-being programs and Accelerated digital revolution. Source: https://unfccc.int/sites/default/files/NDC/2022-06/NDC_submission_20210826revised.pdf
United States of America	North America	The federal administration under President Joe Biden aims for net-zero emissions by 2050, with a national climate agenda that includes tax incentives, funding for energy innovation, and climate-related programs Source: https://www.mckinsey.com/capabilities/sustainability/our-insights/america-2021-renewing-the-nations-commitment-to-climate-action
Australia	Oceania	The Australian Government is implementing a substantial and rigorous suite of new policies across the economy to drive the transition to net zero. Australia's new 2030 target (i.e. reduce greenhouse gas emissions 43% below 2005 levels by 2030) is based on the modelled impact of these policies. Examples would include $20 Bn investment on renewable energy; passage of the National Electric Vehicle Strategy to reduce emissions and accelerate the uptake of electric vehicles and a commitment to reduce the emissions of Commonwealth Government agencies to net zero by 2030 Source: https://www.globalaustralia.gov.au/industries/net-zero#:~:text=The%20Australian%20Government%20has%20made,and%20net%20zero%20by%202050
New Zealand	Oceania	The Climate Change Response Act (2019) provides an enduring framework by which New Zealand can develop and implement clear and stable climate change policies. It achieves this purpose by enshrining in legislation a domestic emissions reduction target by 2050, a system of emissions budgets and emission reduction plans, a climate change commission and adaptation measures. https://unfccc.int/sites/default/files/NDC/2022-06/New%20Zealand%20NDC%20November%202021.pdf
Germany	Europe	Germany presented a package in 2021 to speed up the expansion of renewable energy. This includes new climate legislation in 2021 setting higher national emissions reduction targets for 2030 and 2040, aiming for net greenhouse gas neutrality by 2045. Germany also plans to roughly double onshore wind capacity to 115 gigawatts by 2030 and to increase solar PV installations to 215 gigawatts by 2030. Around a third of Germany's $145 billion spending pledges are aimed at reducing emissions. Sources: https://www.reuters.com/world/europe/germany-present-renewable-energy-expansion-measures-2022-04-05/#:~:text=BERLIN%2C%20April%206%20%28Reuters%29%20,the%20need%20to%20reduce%20the
France	Europe	Launched in 2021, The France 2030 Investment Plan is a 54-billion-euro plan focuses on improving the competitiveness of the industrial sector and supporting the low-carbon transition. France's Green Hydrogen Plan aims to position the country as a competitive and decarbonized economy through innovations in green

Country	Location	Details of green economy plans/policies
		hydrogen. The plan also includes investments of €30 billion to reduce carbon footprint and develop sectors like green hydrogen. Source: Journalism for the energy transition; Green hydrogen plan
Spain		Spain's recovery and resilience plan emphasizes sustainable mobility, energy efficiency, renewables, climate change adaptation, circular economy, and biodiversity. Over €12 billion have been allocated for energy efficiency of buildings and €13.2 billion in sustainable mobility, including green public buses and electric charging stations. Spain also plans to invest €6.1 billion in clean technologies and infrastructure to accelerate the development and use of renewables. Source:https://commission.europa.eu/business-economy-euro/economic-recovery/recovery-and-resilience-facility/country-pages/spains-recovery-and-resilience-plan_en
Italy	Europe	Italy's recovery plan includes €15.3 billion for energy efficiency in buildings and €34 billion for sustainable mobility. It also includes Investments of €11.2 billion in the development of renewable energies and the circular economy. Environmental policy reforms are also underway for the improvement of water resource management, increase of recycling rates, and deployment electric vehicle charging points. Source:https://commission.europa.eu/business-economy-euro/economic-recovery/recovery-and-resilience-facility/country-pages/italys-recovery-and-resilience-plan_en

Source: Various sites

Appendix 2. Specific Technologies for the Environment and Climate Change Operational Area

Agricultural Lands	• Precision agriculture (i.e., precision fertilization, irrigation, and pest and disease detection and management) • Site-Crop suitability matching tools • Remote Sensing for the monitoring of soil conditions. • GIS-Aided Pesticides and Fertilizer Use Information system to keep track of the amount and location of application of pesticides and fertilizers for the assessment of environmental impacts
Watershed	• Comprehensive long-term watershed and ecosystem observation systems–continuously track down the changes in its functions and services, along with the associated changes in the natural (e.g., climate) and socioeconomic drivers (e.g., land use). • Philippine Ecosystem and Watershed Observation Network–adopt protocols of existing international observation networks such as NEON (National Ecological Observation Network of USA), TEAM (Tropical Ecology Assessment and Monitoring), and ILTER (International Long-Term Ecological Research Network).

	• Philippine Ecosystem and Watershed Observation Network–adopt protocols of existing international observation networks such as NEON (National Ecological Observation Network of USA), TEAM (Tropical Ecology Assessment and Monitoring), and ILTER (International Long-Term Ecological Research Network). • Environmental and biological sensors–monitor hydrological processes and soil conditions. • Remote sensing, drones and related technologies–facilitate real-time data collection concurrently over many watersheds and ecosystems that will allow for comparative and relational studies across watersheds and ecosystems in different biogeographic zones. • Watershed decision support systems–process real-time and quasi real-time datasets into information that are vital to making sound science-based management and policy decisions •Watershed and ecosystem models–projection and simulation of watershed and ecosystem responses to changes in climate and development activities • Land use scenario builders–projection of expansion of urbanization, agriculture, land degradation, and deforestation
Coastal and Marine Resources	• Subsea engineering and technology • Sensors and imaging • Satellite technologies • Computerization and big data analytics • Autonomous systems • Biotechnology • Nanotechnology • Drones • Autonomous underwater vehicles (AUVs) • 3D mapping and modeling tools • High resolution and nano satellite imagery, • Suite of monitoring and surveillance tools • Geospatial technology. e.g., remote sensing, geographic information science and spatial statistics
Soil	• Nationwide reassessment of soil resources and setting in place of an integrated decision support system (DSS) consisting at the least of systematic and continuous monitoring of soil health. • Web-based soil and related dataset management system • Widely and readily accessible multiple platform-based soil health assessment tool
Land	• Application of landscape-based (i.e., watershed and ecosystem-based, and ridge to reef approach) local and regional land use planning and development, and agricultural development, and landscape/ecosystem-based. • Practice of sustainable land management (SLM), sustainable forest management (SFM) and multifunction forest landscape restoration, landscape-seascape management and sustainable agriculture (SA) including precision agriculture. • Inherent to the integrated approaches to land use planning and management for robust tradeoff analysis between competing land uses in terms of individual

	and combined net impacts on ecosystems, environment, economy and social welfare. Timber • Robust timber resources tracking system • RFID-aided forest products tagging and tracking technology
Forest and Biodiversity	• Remote sensing and GIS-aided precision tools for the stratification of areas. • ICT for general or targeted IEC programs. e.g. cellular phones and tablets. • Personal digital assistants (PDA) • Electronic diaries • CyberTracker • Species distribution models • Habitat fragmentation analytical tools • Animal Camera Trapping Technology
Climate Change	• Technologies for adjusting cropping calendar, developing flood tolerant rice varieties, diversification of crops and livestock. • Tailor-made adaptation tools and technologies focused on food security, soil and water conservation, resilience of terrestrial, coastal and marine ecosystems, biodiversity and land productivity, and human security. • Nature-based solutions • Real-time online climate monitoring and forecasting dataset and information system of PAGASA freely accessible to the public at will for informed response actions to climate related risks.

Source: NAST (2021, p. 322-323)